VOLUME VI NUMBER 4

BULLETIN
OF THE
AMERICAN ASSOCIATION
OF
PETROLEUM GEOLOGISTS

JULY—AUGUST, 1922

THE BULLETIN is the official publication of the Association, and it is to be published in six numbers with a subscription price of \$5.00 per year. Extra postage on annual subscriptions is 30 cents for Canada and 53 cents for all other foreign countries to which postage is more than the local amount. Communications for the Editor and manuscripts should be addressed to R. C. Moore, Lawrence, Kansas. Remittances and business correspondence should be sent to C. E. Decker, Norman, Okla. Correspondence regarding advertisements should be addressed to J. Elmer Thomas, 751 First Nat'l Bank Bldg., Chicago, Ill.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

*Vol. I	\$5.00	Vol. IV, Nos. 1, 2, and 3, each	\$ 3.00
†Vol. II	4.00	Vol. V	10.00
†Vol. III	5.00	§Vol V, separate number, each	2.00
Vol. IV	7.50	Vol. VI	10.00
		Vol. VI, separate numbers each	2.00

*A few cloth bound copies of Volumes II and III are available at \$1.00 additional.

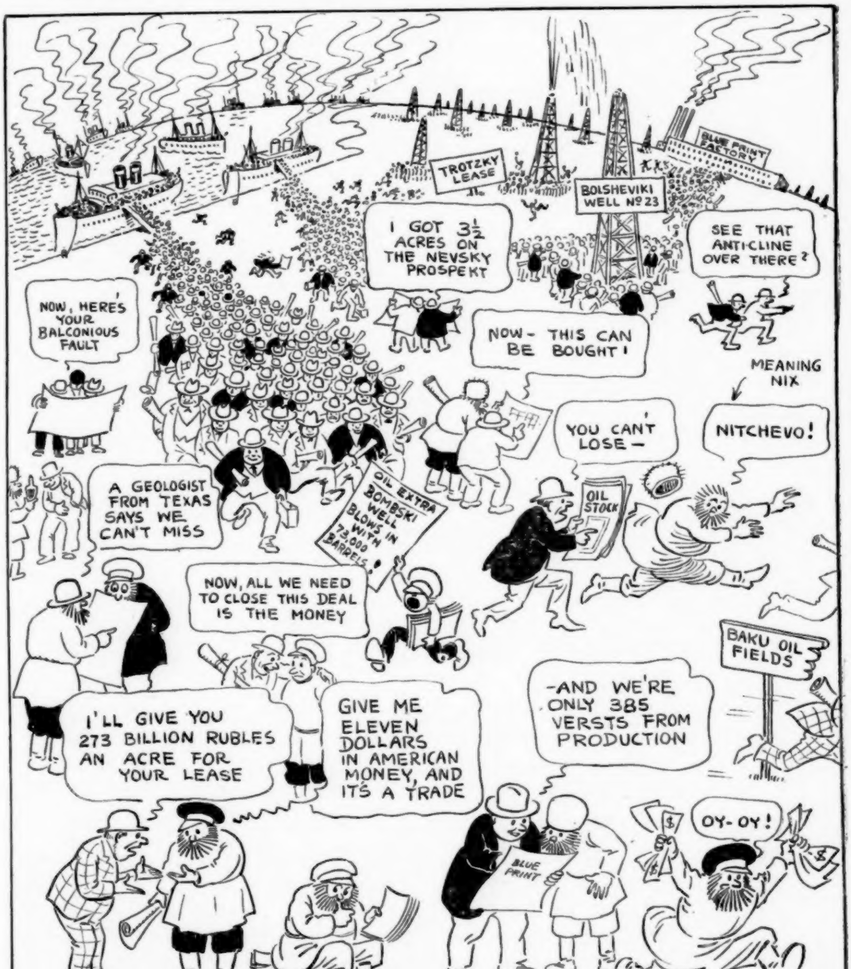
†Only a few copies of Volumes I and II are still available.

§Except No. 2, double size number, \$3.50.

Published by the American Association of Petroleum Geologists bimonthly, at Lawrence, Kansas. Entered as second class matter April 15, 1921 at the postoffice at Lawrence, Kansas under the Act of March 3, 1879. Claims for non-receipt of the preceding Numbers of the Bulletin must be sent to the Editor within three months of the date of the receipt of this number in order to be filled gratis.

CONTENTS

"ATTENTION LEASE HOUNDS! RUSSIA IS GETTING A BIG PLAY!"



—Courtesy of the Dallas Morning News

THE

MID-YEAR MEETING

OF THIS

ASSOCIATION

WILL BE HELD IN

DENVER

OCTOBER 26-28th
1922

SEE DETAILS ON PAGE 348

Volume VI. Number 4.

BULLETIN

OF THE

AMERICAN ASSOCIATION

OF

PETROLEUM GEOLOGISTS

JULY—AUGUST, 1922

NATURAL COAL TAR MISTAKEN FOR OIL RESIDUE[1]

BY GEORGE C. MARTIN

INTRODUCTION

The purpose of this paper is to discuss the possible mistaking of natural coal tar for petroleum residue, with special reference to a reported discovery of petroleum in the Nenana coal field, Alaska. Petroleum seepages and residues are generally and rightly regarded as among the most useful and reliable indications of oil. Although those who are not familiar with oil seepages sometimes mistake iron stains, mineral salts, and living organic slimes for them, it is generally considered that a true seepage is unmistakable. It is important therefore to describe a material which has some of the generally accepted characteristics of petroleum residue but which is believed to be something else. The reasons why there is believed to be no petroleum in the Nenana coal field will be given more fully in an official publication.[2] The present discussion calls special attention to the broader question of the possible general inadequacy of a commonly accepted class of evidence.

It was reported in the summer of 1920 that a petroleum

[1]Published by permission of the Director of the U. S. Geological Survey.

[2]Martin, G. C., A supposed oil seepage in the Nenana coal field, Alaska: U. S. Geol. Survey Bull. 737 (in press).

seepage had been found[3] in the vicinity of Healy Creek, near the south edge of Nenana coal field, Alaska. A sample of sand soaked with bituminous material that was supposed to be petroleum is said to have been subjected to tests in which oils bearing some resemblance to petroleum were extracted by solution. Much interest was aroused thereby and several applications were made for oil leases. The writer made a brief visit to the supposed seepage, where he found reason to suspect that the supposed petroleum residue really was a natural coal tar produced by the distillation of burning coal beds. Chemical tests made in the laboratory of the Geological Survey by E. Theodore Erickson tend to confirm this suspicion.

The reasons for believing that this material is not petroleum residue are:

No adequate original source of petroleum is known in the strata which outcrop at the supposed seepage or in the rocks which underlie them.

The structure is not favorable for the accumulation of oil in the vicinity or for its escape at this place.

If petroleum were escaping here it would almost certainly escape at many other places in the Nenana coal field where it would probably not have been overlooked.

The material differs in smell and composition from most petroleum and contains substances which are generally regarded as characteristic of coal tars.

An adequate source for natural coal tar is found in distillation from coal beds which are known to have burned at many places throughout the field and are believed to have burned at this very spot.

DESCRIPTION OF THE BITUMINOUS DEPOSIT

The locality in question is in Sec. 16, T. 12 S., R. 6 W., Fairbanks meridian, being on the east bank and about a mile above the mouth of Cripple Creek which flows northwest into Healy Creek ,one of the larger eastern tributaries of Nenana River. It is just inside the southern border of the Nenana

[3]Martin, G. C., Preliminary report on petroleum in Alaska: U. S. Geol. Survey, Bull. 719, p. 73, 1921.

coal field which is situated in the northern foothills of the Alaska Range, in the central part of Alaska.

The Nenana coal field[4] contains a thick section of Tertiary (probably Eocene) coal-bearing rocks resting unconformably on igneous and highly metamorphic rocks and overlain by Quaternary gravels. The coal-bearing rocks are between 1,200 and 2,000 feet thick and consist of slightly consolidated sands, clays, and gravels with numerous beds of lignite, there being at least 12 lignite beds of workable thickness, six or more of them exceeding 20 feet, and several being 30 to 35 feet thick. No organic matter was seen, other than the lignite and the usual disseminated vegetable detritus in the adjacent sandstones.

The bituminous deposit, or supposed "oil seepage" is near the top of a steep bank, about 150 feet above the creek. The coal-bearing rocks do not clearly outcrop here, the exposure being of hillside wash mantled with gravel from a terrace on the top of the bank (see fig. 1). The gravel and talus are laid bare in a small area where the soil and vegetation have been swept away, partly by landslides and partly by the wind. Here the sand and soil are soaked with tarry and oily material, which looks and smells somewhat like petroleum, but the smell is somewhat different from that at any seepage which the writer has visited. Shallow trenches do not show any beds that are absolutely undisturbed, but show more of the bituminous material than on the natural surface. The oil or tar is possibly scattered throughout the exposed material, not uniformly. Small irregular masses of sand seem to be completely soaked and have about the appearance and consistency of the tarry sands that were formerly used for sidewalks. The smell is noticeable to one walking over the area and is said to have led to the discovery. The accompanying sketch (fig. 1) shows the relation of the bituminous deposit to the gravels and underlying lignite-bearing beds. This sketch is a copy of a rough diagram furnished by Mr. W. E. Dunkle, who is thoroughly familiar with the locality although he did not have his detailed notes at hand when he

[4]Martin, G. C., The Nenana coal field, Alaska: U. S. Geol. Survey, Bull. 664, 54 pp., 1919.

made the sketch. The sketch indicates conditions substantially in accord with the observations of the writer, and supplies evidence in support of the theory here set forth, although it was made by one who did not have that theory in mind. It should be noted that the five-foot bed of lignite has its position merely indicated in the lower left corner of the sketch. This is where the writer saw no exposure of the lignite but only fragments of clinker indicating that a bed had burned The upper part, only, of this bed is drawn solid in the sketch. This seems to indicate that the fire did not extend to the base of the gravel, but was probably drowned out a short distance below. The bituminous deposit is shown as lying wholly in the gravel, which is in accord with the belief of the writer, and it is situated directly above the place where the fire is believed to have died out. This is the very place where, in accordance with the theory here presented, the tars and oils would condense in greatest amount.

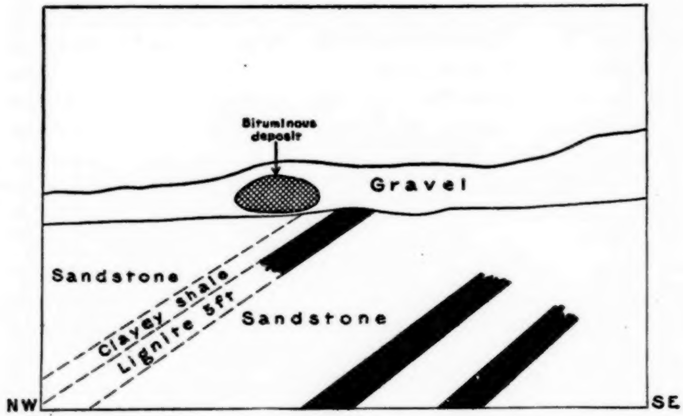


Fig. 1.

GEOLOGIC EVIDENCE THAT THE MATERIAL IS NOT PETROLEUM RESIDUE

The only sedimentary beds known near this place, or elsewhere in the Nenana coal field, which might be considered as a possible source of petroleum are the Tertiary lignite-

bearing beds. These are composed of slightly consolidated sands, gravels, and clays with many beds of lignite. Their organic constituents include only the lignite and the vegetable detritus which is common in sandstone associated with coal. The intervening strata are chiefly sands and gravels with no observable organic constituents. Clays are relatively few and thin, are probably less in amount than the lignite, and are light-colored and notably lacking in organic matter. Carbonaceous or bituminous clays or shales are relatively scarce, or wholly lacking. No beds of limestone, or of diatomaceous or infusorial earth, or any marine or brackish water beds are known. The strata, in brief, contain little or no organic matter from which petroleum might be derived unless it be the remains of the higher forms of vegetable life in, and associated with, the lignites, and these are not generally regarded as a likely source of petroleum. It may therefore be concluded that these lignite-bearing beds are not a possible source of petroleum.

The rocks exposed beneath the lignite-bearing beds include schists and intrusive igneous rocks, chiefly andesites and dacites. It is hopeless to look to these rocks for a source of oil. Moreover, at no place in this region are any rocks known which might be considered as probably oil-bearing. The northern foothills of the Alaska Range are well known geologically for a hundred miles or more both east and west of this locality, and throughout this whole belt the rocks under the Tertiary lignite-bearing beds are chiefly crystalline. It should be noted that there are some relatively unaltered Devonian limestones and Ordovician shales on the north flank of the Alaskan Range, but they have not been seen near this locality and are known only in the high mountains and not in the foothills. The marine Jurassic and Tertiary rocks which contain the known petroleum of Alaska have not been found north of the Alaska Range, except in the Arctic coastal province, and are believed never to have been laid down there.

GEOLOGIC EVIDENCE THAT THE MATERIAL IS TAR

The belief that this material is a natural coal tar produced by distillation from burning coal beds finds support in the

fact that coal beds have burned at many places throughout the field and have probably burned at this very spot. This is, moreover, one of the places where geologic conditions are especially favorable for trapping and condensing the liquids and gases which must be given off whenever a coal bed is burned.

The lignite beds through the entire Nenana field have been extensively burned from unknown natural causes. The burning began at an unknown date, in some places certainly before the deposition of the Quaternary gravels, and some beds are burning now. Although no burned coal beds were seen at the bituminous deposit, the coal beds and imbedding strata not being actually exposed there, abundant fragments of burned clay and masses of slaggy material resulting from the melting of the rocks, were seen in the soil below the deposit. It may, therefore, be assumed that coal has burned at this very place. There is no proof as to when the coal burned here. This fire is not burning now, but the fact that volatile material still remains in the bituminous deposit perhaps shows that the burning was comparatively recent.

It is evident that whenever a coal bed is burning there will be distillation of liquid and gaseous hydrocarbons in advance of the actual combustion. When the coal is heated liquids and gases will be driven off just as they are in making coke or in the artificial distillation of tars and oils from coal and lignite. These liquids and gases will, for the most part, burn or escape into the air but part of them will migrate through the rocks and if they reach cool or damp places they will undoubtedly condense there. The gases given off near the edges of the burned areas are the more likely to escape combustion. If the edge of the burned area approaches, without actually reaching, the surface of the ground the gases are likely neither to burn nor escape, but will in part condense in the damp cool soil.

The special condition favorable for trapping and condensation of distillation products at this locality is the presence of a nearly flat bench of Quaternary gravels lying unconformably across the beveled edges of the Tertiary lignite beds. (See Fig. 1). The surface of this bench, if it is like

the similar nearby benches, is dotted with marshy areas and pools of water. The materials composing the bench are doubtless either wet or frozen. A fire in the lignite would probably approach, without reaching, the base of the gravels. The gases and liquids given off from the burning and distillation would be trapped under the wet or frozen gravels and would in part condense there.

The natural burning of coal beds is well-known, but the published descriptions deal with the destructive effects on the coal beds and with the fusion of the overlying rocks, with no reference, as far as the writer knows, to the condensation products from the distillation of the coal. The reason for this omission is believed to be that, in most regions, the coal burns vigorously to the very outcrop so that, the distillation products either burn or escape into the air at the places where they might otherwise be most easily seen. The gases given off at great depths will, mostly, be diffused through buried rocks where their condensation products can not be seen till these buried rocks are laid open by natural or artificial excavation. The fact that natural tars have not been generally noted may also be due to the general lack of a wet or frozen cover. Generally either the rocks are wet to great depths in which case the coal does not burn, or else they are dry to the very surface, in which case they heat to the surface and the gases escape.

CHEMICAL TESTS

In order to obtain evidence as to whether the organic matter in the supposed seepage was actually derived from distillation of coal, samples have been studied by E. Theodore Erickson in the chemical laboratory of the Geological Survey. The following report was submitted on three samples collected by the writer, all from the same locality. Sample A is a selected sample made up of numerous small samples of the more bituminous black sand. Samples B and C are representative selections of the less bituminous (average) finer and coarser material:

Sample A: A chloroform extract indicated a small part of bitumen together with considerable soluble sulphur. The bitumen when heated with alkali solution and likewise the sample when so directly treated,

yielded strong odors of the pyridine series of compounds. Red litmus paper in the emitting odors readily turned blue. The intensity of these results are sufficient to estimate a considerable amount of these substances to be present in the comparatively small amount of bitumen in the sample.

Phenol like compounds were detected by the following procedures. The sample was treated directly with strong boiling alkali solution. The alkali extract after filtration from insoluble matter was acidified with HCl, boiled gently and a second filtration made. The final filtrate was colored reddish with organic matter, an ether extract was made, and upon evaporation of the ether a small amount of reddish organic matter remained. It possessed a phenol-like odor and when dissolved with a small amount of water the aqueous solution gave with dilute ferric chloride solution a positive reddish violet color. Pure phenol under the same conditions gave a bluish violet color. The phenol like residue when heated in the usual way with a small amount of two parts of H_2SO_4 and one part of HNO_3 gave the yellow color of the picric acid test. There were obtained the characteristic phenolic results of a moderately colored yellow solution in water, which deepened much upon the addition of ammonia. Phenolic compounds were detected in the phenol like residue by dissolving in 20 c. c. of normal NaOH solution and adding a small amount of diazobenzene chloride solution. A reddish color and precipitate were obtained identically as for small amounts of pure phenol. Under the same conditions negative results were obtained in a blank test and in a second blank test containing a small amount of pyridine.

There is also present some pyrobitumen or chloroform insoluble bitumen in the sample. A trace of arsenic and considerable free sulphur were detected.

A determination of the amount of soluble material in Sample A, using carbon disulphide as the solvent, showed 3.6 per cent of bitumen and 7 per cent of soluble sulphur. In this test carbon disulphide was used as the solvent ,instead of chloroform, because it was found to yield a better separation of sulphur and bitumen upon evaporation.

Sample A was heated for 10 days at 105°C. when it showed a total loss of 10.42 per cent, which is believed to be chiefly moisture as considerable water and no observable oils condensed. The sample gave an odor of volatile substance both before and after the heating.

Sample B: A chloroform extract indicated a small amount of brittle bitumen. It gave pyridine and phenolic indications but not as intense as in Sample A. Free sulphur did not separate out from the choloform evaporated extract as in Sample A. It contains practically no arsenic and a slight amount of pyrobitumen.

Sample C: The amount of bitumen obtained from Sample C was intermediate in amount bewteen that of Samples A and B. The free sulphur obtained was less than in Sample A. The pyridine and phenolic indica-

tions are also intermediate between those of Samples A and B. There is present not over a trace of pyrobitumen and practically no arsenic.

The detecting of the pyridine series of compounds together with appreciable amounts of phenol like compounds in the organic matter in sample A may be considered as evidence that there are present coal tar products that have resulted from the destructive distillation of coal. To differentiate the bitumen from a natural petroleum bitumen and asphalt on these grounds becomes tenable when it is considered that petroleum in general contains small amounts of these substances especially the phenol like bodies. The diazobenzene chloride test is considered by Marcusson[5] to give for natural asphalt and petroleum pitch a yellow or orange color and not the reddish colored results above which are obtained from lignite-tar pitch which contains phenol.

Loebell[5] uses the diazobenzene chloride test to differentiate coal tar pitch from natural or petroleum asphalt, the latter giving negative results with this test.

Of the nitrogen constituents in petroleum it appears likely that allowance must be made for the presences of hydrochinolines other than the pyridine series of compounds as is evident in Maybery's work on the California petroleums.

It is understood that the samples here tested are directly connected with the natural combustion of coal, with which the results here reported align themselves.

Mr. Erickson shows above that the customary tests for distinguishing coal tar pitch from petroleum pitch or natural asphalt indicate that all three samples contain coal tar pitch. These tests are based on the presence in coal tar of certain compounds, notably phenol- and pyridine-like compounds, which are rare or lacking in most petroleum. The tests show that substances related to phenol and pyridine are present in comparatively large amounts and indicate that the material is a coal tar rather than a petroleum residue. The large quantity or sulphur is a further indication that the material was derived from burning coal, because although sulphur is a common constituent of petroleum, it usually occurs in only small quantities. Sulphur occurs also in all coals and lignites from which it would be easily volatilized and condensed, and is a common and troublesome constituent of the tars which are artificially distilled from lignites. The chemical tests might possibly be considered as not absolutely conclu-

[5]Holde, D., The examination of hydrocarbon oils and of saponifiable fats and waxes (English translation by Edward Mueller), p. 222, 1915.

sive, since phenol and pyridine have been recognized in small amounts in a few petroleums, notably in some from California. Moreover, the writer would suggest that perhaps these substances may occur in larger quantities in petroleum residues than they do in live oils, but since Mr. Erickson's studies tend to confirm the conclusions drawn from the geologic field relations there is believed to be little doubt that this material is a natural coal tar and not a petroleum residue.

NEW OIL FIELDS OF THE LOS ANGELES BASIN, CALIFORNIA.

By Ralph Arnold and Wayne Loel.

INTRODUCTION.

The following paper has been prepared to meet a demand for a concise review of the recent developments in the oil fields surrounding the city of Los Angeles. It is based largely upon information gathered during the course of professional work within the last few years, and upon data secured by the senior author while engaged in investigations for the U. S. Geological Survey and for the U. S. Bureau of Mines. The figures used in the compilation of the curves were taken from the bulletin of the Standard Oil Company of California.

DEFINITION OF THE LOS ANGELES BASIN

The Los Angeles Basin may be defined as the area of low relief rising from the ocean on the west and shut in on the north by the Santa Monica Mountains, on the east by the Puente Hills and Santa Ann Mountains, and on the south by the San Joaquin Hills. Within these boundaries lies approximately five hundred square miles of territory, of which a small proportion is productive of petroleum.

LOCATION OF THE OIL FIELDS

The three principal producing areas of the Los Angeles Basin are:

(1) The Los Angeles group or district including in order from west to east the Beverly Hills field, the Salt Lake field and the Los Angeles City field,

(2) The Whittier-Fullerton or Puente Hills group, including Montebello, Whittier, Puente, Brea, Olinda, Kraemer, Richfield, Fullerton, Coyote, and the newly discovered field at Santa Fe Springs, and

(3) the Beach group including Huntington Beach, Long Beach and Redondo.

Genetically speaking, the Beverly Hills field lies on the same structural line as the beach fields, but for all practical purposes it is best described with the Los Angeles fields.

The Montebello field, lying several miles east of the city of Los Angeles, constitutes the westernmost of the Whittier-Fullerton group. Development in this field has been extended in a southeastern direction, until the Montebello field almost merges with Whittier Heights. East of the Whittier field is a barren area three or four miles in extent, following which, in a southeasterly direction along the southern slope of the Puente Hills, is an unbroken succession of wells for several miles, known as the Brea-Olinda field. The old Puente field, the first to be developed in the Los Angeles basin, lies in the heart of the Puente Hills about a mile northwest of the Brea field.

The Kramer field, the easternmost extremity of the Los Angeles Basin area, lies in the mouth of the Santa Ana Canyon. Immediately west of Kraemer is the recently developed Richfield district, and northwest of the latter is a large group of wells designated as the Fullerton field. Almost merging with this group to the west are the wells in the Coyote Hills. Three to five miles northwest of the Coyote field lies the new territory surrounding Santa Fe Springs.

The Huntington Beach field, situated in the outskirts of the town of Huntington Beach, is one of the most recent developments in the Los Angeles Basin area, having been brought in practically within the year. Another of the recent fields lies on Signal Hill, in the northern part of the city of Long Beach and is known as the Long Beach field. A single well, about two miles east of Redondo, has been made to produce some oil, but owing to the condition of the hole at present its productivity is uncertain. This may be the nucleus of a new area of production which will be known as the Redondo field.

A little to the north of the Puente Hills and outside of the Los Angeles Basin some drilling has been undertaken on what is known as the Puente dome, situated a mile northeast of the town of Puente. While this does not fall within the basin proper, it should be considered as a part of the Los Angeles district and may become a small producing pool, although, to date, no actual production has been attained.

On the east side of the Puente Hills, midway between the

towns of Chino and Corona, two wells have shown some oil and give promise of a small field in this locality.

GEOLOGIC FORMATIONS

The principal formations involved in the geology of the

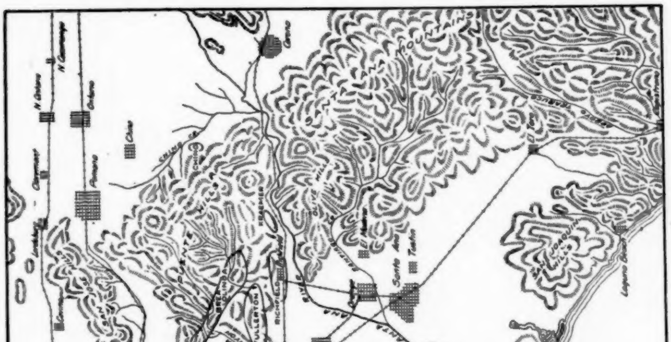


Figure 1.

Los Angeles Basin, in order of age beginning with the oldest, are: Jurrassic or pre-Jurrassic crystalline rocks; the Franciscan of probable late Jurassic age; the Chico of Cretaceous age; the Martinez and Tejon of Eocene age; the Sespe of

Oligocene age; the Vaqueros and the Puente of Lower Miocene age; the Fernando, which includes beds of Upper Miocene and Pliocene age; and the San Pedro and terrace gravels of Pleistocene age. The commercial quantities of oil are confined to the Miocene and Pliocene. The geologic column for the Los Angeles Basin district is shown in the accompanying tabulation.

Since the senior author's publication of the geology of the Los Angeles district in 1907[1] much detailed work has been done, which makes many refinements possible in the geologic column for Southern California. Since the results of later work have not yet been published, it is deemed inadvisable to incorporate at this time new ideas which might prove confusing without a suitable discussion of the reasons for the change, a thing impossible in a paper of this nature.

Period	System	Series	Los Angeles Basin Section	Thickness in feet
Cenozoic	Quaternary	Recent Pleistocene	Alluvium, Terrace-Gravels, San Pedro	1,000
			Unconformity	
	Tertiary	Pliocene Upper Miocene	Fernando	2,000 to 3,500
			Unconformity	
		Lower Miocene	Puente...... Upper	300—2000
			Puente...... Middle	300—2000
			Puente...... Lower	2,000
			Unconformity	
			Vaqueros	1,000
			Unconformity	
		Oligocene	Sespe	2,200
			Unconformity	
		Eocene	Tejon	1,300
			Unconformity	
			Martinez	1,500
			Unconformity	
Mesozoic	Cretaceous	Upper Cretaceous	Chico	2,500
			Unconformity	
	Jurassic		Franciscan	More 8,000

[1]U. S. Geological Survey, Bull. 309, 1907.

A brief description of the principal divisions follows.

Basement Crystalline Complex.

Under this head are grouped granite, schistose and strongly metamorphosed crystalline rocks which make up the cores of many mountain ranges of Southern California, including those of the Santa Monica and Santa Ana mountains.

Cretaceous.

Chico. Of the Cretaceous only the upper part or rocks of Chico age are found in the Los Angeles Basin area. These occur principally in the Santa Ana and Santa Monica mountains and lie directly on the basement complex. They consist of hard sandstone with some thin-bedded, dark-colored shales, with a coarse conglomerate at the base. These rocks reach a maximum thickness of about 2500 feet and are not productive of oil in this part of the state.

Eocene.

Minor isolated outcrops of Eocene rocks occur in the Santa Ana mountains. The series is divided into two parts, the lower member being known as the Martinez, the upper as the Tejon.

Martinez. The Martinez is represented by a reddish-brown clay having a thickness of about 1500 feet.

Tejon. The Tejon is a buff, fine-grained sandstone having a thickness of 1300 feet.

The rocks of Eocene age are, like the Cretaceous, unproductive of petroleum in the region of the Los Angeles Basin.

Oligocene.

Sespe. Beds, opproximately 2,200 feet in thickness, believed to be the equivalent of the Sespe formation of Ventura County, are found in the Santa Ana Mountains. The sands and shales in particular are usually brilliantly colored red, purple and green. No fossils are found in the formation and no oil, so far as known, has been found in it in this district.

Lower Miocene.

Vaqueros. The Lower Miocene of the Los Angeles Basin is divided into the Vaqueros and Puente formations. The former consists of sandstones, clay-shale and conglomerate.

The sandstone is usually gray or buff in color, with the shales darker or even purplish. Although there is no line of unconformity or other sharp line of distinction within the Sespe-Vaqueros series where exposed in this district, the upper 1000 feet are included in the Vaqueros, largely on lithologic grounds. The formation is fossiliferous, but non-oil bearing, except, possibly in the old Puente field north of Brea.

Puente. The Puente, or Monterey formation as it is known elsewhere in the state, is considered by far the most important as regards the source of petroleum, and in many instances the sandy strata in the upper part act as the reservoirs from which the oil is obtained.

In the Los Angeles Basin this formation is divided into three parts: a lower diatomaceous shale member, a middle zone composed principally of sandstones, and an upper division in which sandy and argillaceous foraminiferal shales containing considerable amounts of mica predominate over siliceous and diatomaceous shales.

Along the northeastern border of the basin the shales of the Puente are predominantly diatomaceous, but become more sandy to the south in the region of El Toro, the most marked line of transition being along Santa Ana River, this condition accounting for the lack of commercial deposits of oil south of this boundary.

The lower Puente shales reach a thickness of 2000 feet in the Puente Hills and may be in part of Vaqueros age. In the city of Los Angeles the relationship of this part of the formation to the underlying rocks is obscured by faults. The middle sandstone member varies in thickness from 300 feet in the eastern Puente Hills to more than 2000 feet in the vicinity of Los Angeles . The upper shale zone varies in a similar manner to the sandstone member and is approximately equal to it in thickness.

Upper Miocene-Pliocene.

Fernando. The early workers in Southern California geology placed all rocks later than the Puente in one series known as the Fernando formation. This was made necessary by reason of the fact that the separation of the beds on a litho-

logic or paleontologic basis was found to be extremely difficult and could not be undertaken with the meager data at hand. More careful investigations have shown that the Fern-

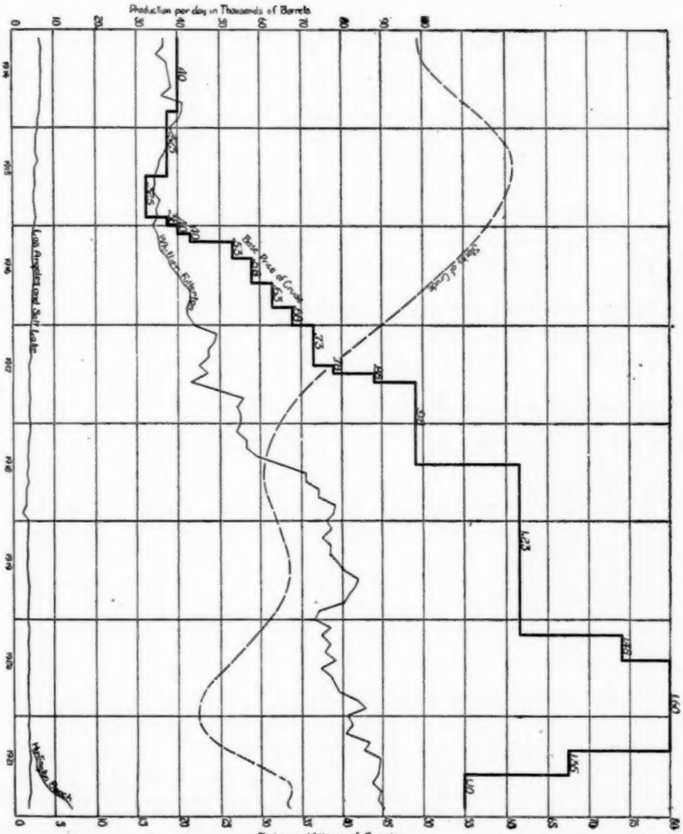


Figure 2. Production curves for the fields of the Los Angeles district, stocks for the state and base price for crude oil since 1913

ando may be divided into two parts—the lower being Upper Miocene in age, corresponding to the Santa Margarita formation of central California, while the upper portion lies in the Pliocene. Since the point of division has not been well

established south of the Santa Monica Mountains, the old inclusive usage of the formational name will be adhered to in this paper.

The basal portion of the Fernando is made up of blue and gray argillaceous shales and soft sandstones. These grade upward into conglomerates, soft gray shales, and gravels. The sandstone members of this series form many of the petroleum reservoirs in the southern portion of the state. The Fernando varies in thickness from 2000 to 3500 feet.

Recent-Pleistocene.

San Pedro-Terrace Gravels. The Pleistocene is represented by a series of gravels, loose sands and sandy clays, not distinguishable from the underlying Pliocene except on a paleontologic basis. An occasional heavy oil or tar sand is encountered in the lower beds of this series which reaches a maximum thickness of about 1000 feet.

GENERAL STRUCTURE

Broadly speaking, the axes of the major structural features of California parallel the coast line. This condition obtains in the Los Angeles Basin district with slight modifications. The uplift of the Santa Ana Mountains is the controlling structural feature on the east, while that of the Santa Monica Mountains forms the northern rim of the basin. The compressional forces from the west have been exerted upon rocks which lie beneath the ocean some distance from the shore and are evidenced only in a minor degree in the uplift of the San Pedro Hills.

Between the Santa Ana Mountains and the sea lies a broad synclinal valley the axis of which extends from the southwestern limits of the city of Los Angeles to the vicinity of El Toro. The western flank of this syncline rises to what is known as the Inglewood line of uplift, taking the form of an anticline with beds gently dipping to the east, but with a more steeply inclined western limb modified in places by faulting. This major line of folding extends in a southeasterly direction from the Beverly Hills field at the base of the Santa Monica Mountains on the north, through Dominguez Hill, Long Beach, and Huntington Beach, to the south.

Between the Inglewood uplift and the coast lies a second and much smaller syncline, the axis of which runs parallel to that of the uplift from a point midway between Santa Monica and Palms, through Nigger Slough and the city of Long Beach.

Between this syncline and the San Pedro Hills to the southwest a minor anticlinal condition may exist, but is only faintly suggested at the surface by the topography. The idea of such a condition is borne out, however, by the fact that the oil well east of Redondo has given evidence of being a commercial producer.

The compressional forces induced by the elevation of the Santa Monica Mountains formed a series of cross folds wherein accumulated the oil of the Los Angeles and Salt Lake fields.

The Puente Hills, which form the northeastern rim of the Los Angeles Basin, are the result of the same forces, diminished in intensity, which caused the rise of the Santa Ana Mountains. The direction of dominant stress was from the northeast, causing the beds along the southwest slope of the hills to be faulted and sharply tilted, producing a monoclinal condition in the Whittier and Brea fields. To the west the compressional forces were less intense, allowing the formation of a normal anticline in the Montebello field.

From the main uplift of the Puente Hills several minor folds branch off to the west. On these are situated the Kraemer, Richfield, Fullerton, Coyote Hills, and Santa Fe Springs fields.

DESCRIPTION OF NEW FIELDS

The older producing fields of the Los Angeles district have been in existence for so many years and are so widely known in detail that further discussion of them should not be entered into here. These fields are described in detail by Eldridge and Arnold in Bulletin 309, U. S. Geological Survey.

The four new fields—Richfield, Huntington Beach, Long Beach, and Santa Fe Springs—may be briefly described as follows:

Richfield. The Richfield district lies at the base of the Puente Hills in an area of low relief without marked topo-

graphic features which might indicate the presence of subsurface structure.

The discovery well was brought in in the fall of 1919, at a depth of 2900 feet, with an initial production of 3000 barrels per day, which rapidly increased to double this amount. This well was quickly followed by others, varying in daily production from seventy-five to several thousand barrels. The producing wells now cover an area two and a half miles long by a mile wide.

The structural condition of the field is that of an anticline modified slightly by cross folding. The axis runs in a general east-west direction with the plunge to the west.

There are two producing zones, slightly unconformable, the upper of which is in the base of the Fernando, while the lower is probably in the upper part of the Puente. The stratigraphic distance between the oil horizons is approximately 1000 feet. The lower zone yields the best oil, although there is a considerable variation in gravity in both zones in different parts of the field.

The wells range in depth from 2700 feet to 4300 feet, while the gravity of the oil varies from 16° B. to 27° B. The average daily production per well is now in the neighborhood of 160 barrels.

Huntington Beach. The Huntington Beach field lies on the coast at the extreme southern end of the Inglewood line of uplift. A low hill near the center of the field is the only topographic feature which might indicate an anticlinal condition of the beds beneath.

The discovery well was brought in in the late summer of 1920, at a depth of 2700 feet, with an initial production of 1800 barrels per day. Immediately, a most intensive drilling campaign was started by innumerable small companies with holdings ranging from one city lot to several acres each, with the result that within a year over fifty wells were brought in. The average daily production per well at present is about 300 barrels. The proven territory now covers an area approximately three miles long by a little over a mile wide.

The structural condition of the field is that of an elongated dome, modified by several minor cross folds. The major axis

extends in a northwesterly-southeasterly direction, paralleling the coast line.

Two major zones of production exist—an upper, known locally as the Bolsa, and a lower, referred to as the Ashton. The producing horizons are separated stratigraphically by approximately 450 feet. A slight unconformity exists between these horizons, similar to that in the Richfield district, the Bolsa sand probably being in the Fernando formation while the Ashton horizon may lie in the top of the Puente. Formational correlation in this field is extremely difficult, owing to the great lithologic similarity existing between the beds of the two zones.

Very careful work is now being done by the larger companies in developing this field, and numerous core samples are being taken from drilling wells with the object of determining the structural conditions with greater exactness than has heretofore been deemed necessary. The detailed microscopic examinations now being made of the core samples are bringing to light new facts regarding underground conditions, resulting in many cases in greatly increased production.

The difference in the gravity of the oil produced from the two zones is quite marked, that of the lower zone running as high as 28° B. while the average gravity of the oil from the upper zone is only 20° B. The wells range in depth from 2000 feet to 4200 feet.

Long Beach. The wells of the Long Beach field lie on the slopes of Signal Hill, which rises to an elevation of 300 feet and is a part of the Inglewood uplift. No indication of subsurface structure is visible on Signal Hill except in the steeply tilted beds of Quaternary age.

The discovery well on Signal Hill was brought in during the latter part of June, 1921, at a depth of 3000 feet, with an initial flow of 1,000 barrels daily. At the present writing there are eight wells producing, but none so far has equalled the discovery well. The new wells have not been producing long enough to permit any conclusions regarding the future of the field. The proven territory at present would appear to cover an area approximately one and a half miles long by one-half mile wide.

The structural condition of the field is that of an anticline broken by both longitudinal and transverse faults, the magnitude of which cannot be determined until more wells have been drilled.

Two zones of production occur in this field, as in Huntington Beach, but the data concerning underground conditions are so meager at present as to render further discussion impossible. Owing to the complicated structural conditions brought about by faulting, the companies are carrying on development slowly and are using every precaution to determine the structure with great exactness. The oil ranges in gravity from about 18° to 25° Beaume. The wells now producing in the field vary in depth from 3000 feet to 3300 feet. Some deep wells are being drilled but have not as yet reached any producing sands.

Santa Fe Springs. The new field of Santa Fe Springs is located about two and a half miles southwest of Whittier.

Drilling in this vicinity has progressed for several years, a number of wells having been sunk to four and five thousand feet without encouraging results. The discovery well, a little south of the Santa Fe Springs station, was the first one to produce a sufficient quantity of oil to cause excitement. This well came in the last week in October, 1921, at a depth of 3780 feet, with an initial production of 2000 barrels per day of 31° B. oil. At the present writing this production has increased to 4000 barrels per day. A large number of wells are now being drilled in the vicinity, with the expectation that a field of considerable extent will be developed.

There is little surface evidence outside a low topographic ridge in the Santa Fe Springs area to serve as a guide in determining the structure, but from a consideration of the regional geology the axis of this field should lie in a northwesterly-southwesterly direction, and is probably a continuation of the Coyote Hills anticline.

PRESENT AND FUTURE PRODUCTION

Although the oil fields of the Los Angeles Basin are among the oldest in the state, the first producing well having been drilled in 1880, the peak of production has not yet been

reached. The discovery of new fields has kept pace with the increase in demand so successfully that, at the present writing, production exceeds consumption, with the result that oil has been going into storage rapidly since the beginning of 1921.

In Fig. 2 are shown the production curves for the fields of the Los Angeles district, together with the stocks for the state and the base price for crude since 1913.

The relationships of these curves are very interesting. The economic effect of the war is plainly shown. From the outbreak of hostilities in 1914, when our exports were shut off, until the summer of 1915, when the industrial conditions in this country had become readjusted, the stocks of crude rose to a peak of 62 million barrels with a corresponding drop in price to 32½ cents per barrel. From this time on until the end of the war it was impossible to keep production up to the demands of industry, with the consequence that stocks diminished rapidly and the price rose as never before in the history of the California industry.

The effect of these conditions was to stimulate drilling. The production of the Los Angeles-Salt Lake field could not be increased since it was already completely developed, but by the beginning of 1918 production in the Whittier-Fullerton district began to increase rapidly and wild-cat drilling was in progress everywhere. The increased drilling campaign had its effect in arresting the downward trend of the "Stocks Curve" during 1918 and the early part of 1919, but the new wells soon began to drop off in production, so that in the latter part of 1919 the stocks again began to dwindle rapidly, reaching a minimum of 22 million barrels in December, 1920. The price rose to its peak of $1.60 per barrel in the summer of 1920, but has declined since in proportion to the increase in storage.

In the fall of 1919, the newly-discovered Richfield district began to add its oil to the Whittier-Fullerton production, once more starting the production curve for that field upward.

The sharp decline in the "Stocks Curve" during 1920 was partly due to the curtailing of production in the San Joaquin Valley fields during the oil workers strike.

The subsequent rise of the curve during 1921 was affected

not alone by the increased production in the Los Angeles district, but also by the bringing in of the Elk Hills field, in the San Joaquin Valley, in the fall of 1920.

Since the beginning of 1920 the Whittier-Fullerton curve has continued to rise, because of development of the Richfield district. If the Santa Fe Springs field approaches Richfield in productivity, the curve may not reach its peak for several years, while the new fields of Huntington Beach and Long Beach may keep up the production for the entire district for some time. However, it must be evident that the continual discovery of new fields can not go on indefinitely, and within the next few years the beginning of the final decline of the Los Angeles Basin fields will be at hand.

REMARKS ON SUBSURFACE CONTOURING

EDWARD BLOESCH

The geologists working in the Mid-Continent Field have found out the importance of subsurface structure, as it varies considerably from the surface structure on account of unconformities and changes in thickness of certain formations.

The best method to work out the subsurface structure in a territory of low structural features like the Mid-Continent Field is by way of structure contours on a certain horizon shown in well records. Such a horizon should be close to the probably producing zone, as the main use of a subsurface map is to predict oil or gas possibilities. It should not be separated from this zone by a marked unconformity. Quite often it is advisable to contour different subsurface horizons in the same area on account of the presence of a number of unconformities.

As a rule it is not an easy matter to pick out a proper horizon on which to base subsurface contours. It ought to be a formation of regular thickness, preferably thin, which extends over all the territory to be mapped. The best formations are generally thin limestones and coal beds. Unfortunately the drillers do not pay enough attention to these formations and many well logs do not contain them or do not show their thickness and depth accurately. Therefore it is cften necessary to use sands which are known to be lenticular and of variable thickness. Quite often the top or the bottom of such a sand is used for contouring just as it is given in the log. A sand surface is not generally deposited on a level. The currents, which erode even locally, wash the sand into low wavy ridges. Furthermore the deposition of a massive sandstone does not terminate abruptly. In one place shale or sandy shale is deposited, while in another sand is still being washed in. Even where sand deposition is abruptly terminated by shale, sedimentation turns to sand again, chang-

---

Edward Bloesch, Consulting Geologist, Tulsa, Oklahoma.

ing several times before the sediment is pure shale. In studying the sandstones of the Mid-Continent field at the surface, these minor ledges are often observed above the main sandstone. In doing surface work it is comparatively easy to tell on which ledge one is working. The average well records do not give these minor ledges separately. One driller will include them in the shale, while another one will put them and the intervening shale together with the main sand. Therefore a map contoured on a sand surface is not a structure map proper. The same is true of a map contoured on the base of a sand, but in a less degree, as the change in deposition from shale to sandstone is usually more abrupt than from sandstone to shale. The difference between such a sand surface map and a real structure map is negligible in a territory where the folding is fairly pronounced, as for instance in the Appalachian oil fields. In the Mid-Continent field with its low dips, however, where a contour interval of ten feet is customary, it is often important, as it may influence the conclusions drawn from the contour map. Therefore it is advisable to check the drillers records and to use in some logs, where the reported sand is of abnormal thickness a horizon within the sand, and in logs where the sand is evidently too thin, to use a horizon above the sand shown in the log. The proper horizon to be used in each log can be determined by comparing top and bottom of the sand and other formations of the log which are not separated by unconformities from the sand to be contoured.

In order to make this plain reference may be made to the accompanying Plate I, where five logs from sections 14 and 15 in T. 13 N., R. 15 E. in western Muskogee county, Oklahoma are plotted.

The only horizon which can be identified with certainty and which is reported in all the five logs is the "Glenn" sand or Salt sand of the drillers. The thickness of this sand varies so much in the well records, that neither the top nor the bottom can be used as recorded for structure contours. Suppose a structure contour map had to be drawn on top of the "Glenn" sand. Only in logs Nos. 2 and 4 the actual top of the sand designated by a coal bed could be used. In No. 5 an abnormal

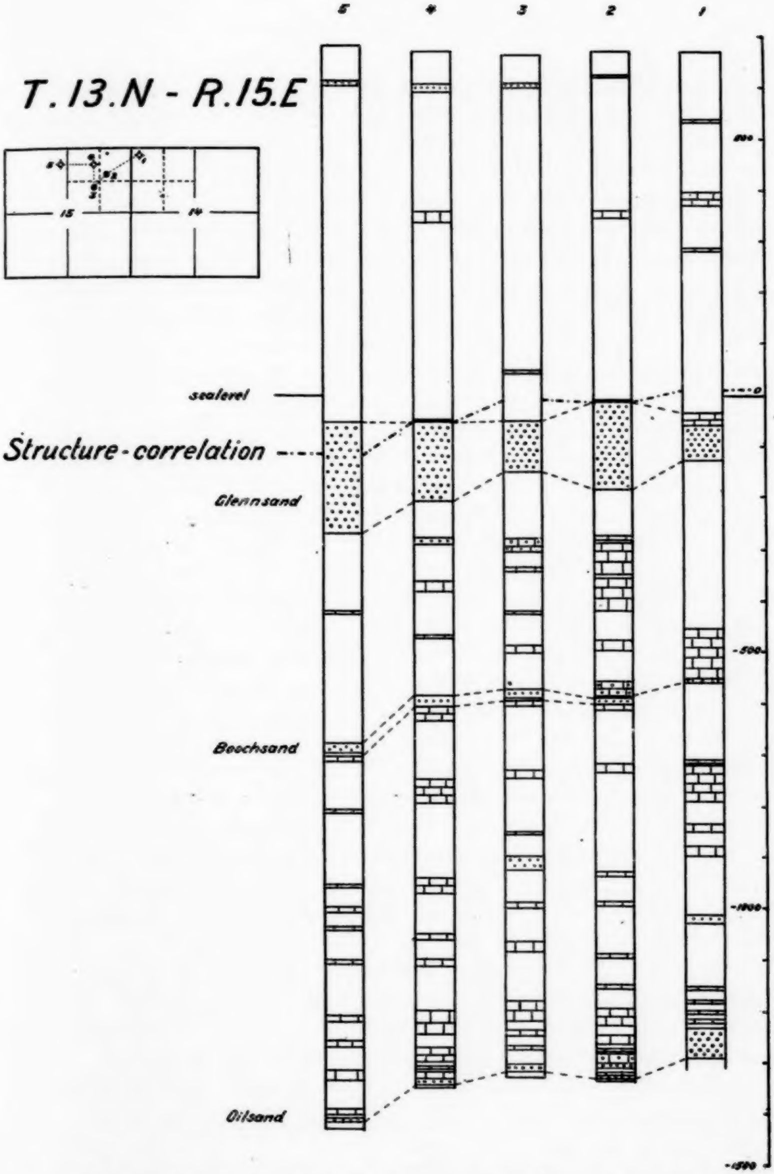


Plate I. Illustrating relation between sand surface and proper structure correlation.

sand thickness is given, so that a point below the top as shown on the plate should be used. In Nos. 1 and 3, where the sand is reported abnormally thin, the horizon above the sand should be taken. In order to determine these points, the bottom of the "Glenn" sand and other horizons, for instance the Booch sand have to be consulted. If the top of the "Glenn" sand as shown in the logs be used, it would give valuable information as to accumulation of oil and gas in the "Glenn" sand. But where conclusions on the structure of lower formations are to be drawn, the proper structural correlation as shown on the plate is much more valuable. As can be seen it runs almost parallel to the oil sand producing in this place.

Contours on a sand surface, even where they differ considerably from real structural contours, have a certain value in studying gas and oil accumulation or the water level in a particular sand and contours on the bottom of a sand are also important for such questions. For purely structural deductions, for instance the relation between surface and subsurface structure or predictions on horizons below the contoured sand, real structure contours are more valuable.

Sand surface contours often show local irregularities, which have nothing to do with structure and only tend to cloud the general outline and real nature of the structure. One can almost tell by looking at some contour maps, that they represent a sand or erosional surface.

On Buttram's[1] structure map of the Cushing field the main part of the area is contoured on the Pawhuska limestone. Only in the vicinity of Drumright, where the Pawhuska is eroded, elevations of the Layton and Wheeler sands from well logs were used, figured on the Pawhuska using a constant interval. This part of the map has an entirely different character from the other one. Instead of major folds it shows a number of small, very irregular domes. The writer does not consider these features as structural. They are the irregularities of the sand surface as reported in the well logs.

Even the subsurface maps of the Cushing field by Beal[2]

[1]Buttram, Frank, The Cushing Oil and Gas Field, Oklahoma, Okla. Geol. Surv. Bull. 18, plate 1, 1914.

[2]Beal, Carl H., Geologic Structure in the Cushing Oil and Gas Field, Oklahoma, U. S. G. S. Bull. 658, plates 7, 8 and 9, 1917.

on the Layton, Wheeler and Bartlesville sands with a contour interval of 25 feet show local irregularities, which reflect sand surface rather than structure. That this is the case is emphasized by the fact, that some of these local features of one sand surface are not indicated on the map of the deeper sands. The Layton sand in particular seems to have an irregular surface or it has not been properly interpreted by the drillers.

Fath[3] in his recent bulletin on the Eldorado, Kansas, field discusses the influence of irregularities of the surface of the 660-foot sand on the structure contours of this sand.

A very interesting sand surface is shown by Berger[4] in his "Subsurface Structure" map of the Sallyards field, Kansas, with contours on top of the Sallyards sand. This sand is lenticular and thins or even pinches out at the edge of the producing area. Therefore the bottom of the sand would show contours entirely different from the top. This sand surface is not real structure as horizons below and above (see surface structure) have a different configuration. While it governs the accumulation in the Sallyards sand, conclusions from this "Subsurface structure" on other deeper sands would be misleading. The Sallyards field may help to solve the question whether the domes and anticlines in the Mid-Continent Field have been formed by lateral compression or if they are due to differential settling. If the bottom of the Sallyards sand shows a relief similar to the surface structure or to the structure of a limestone not far above the sand, then differential settling had very little effect. On the other hand if there is no relation between sand bottom and the structure of the upper formations, it is a case of differential settling.

It may be necessary to contour on an erosional surface at the base of a slight angular unconformity. The contours on top of the Boone limestone in the Independence quadrangle[5],

[3]Fath, A. E., Geology of the Eldorado Oil and Gas Field, Butler County, Kansas. State Geological Survey of Kansas Bull. 7, p. 77-79, 1921.

[4]Berger, Walter R., The Relation between the Structure and Production in the Sallyards Field, Kansas, Bull. Amer. Assn. Petroleum Geol. Vol. 5, No. 2, 1921.

[5]Schrader, F. C., U. S. G. S. Folio No. 159, Independence, Kansas, 1908.

Kansas, probably the first ones published in the Mid-Continent field, are of this nature. They do not represent actual structure but only an approximation to it. In subsurface work in or below the Mississippian it is almost impossible on account of the various unconformities to make a contour map which is absolutely sure to be a real structure map. We will be able to improve on this with better well records and better knowledge of the stratigraphy of these formations in the Mid-Continent field.

Fath[6] gives a subsurface structure map of the Eldorado, Kansas, field contoured on top of the Stapleton oil zone. As he considers the top of this zone an erosional surface truncating several formations, his contours do not show the structure proper but the form of that surface. This probably accounts for the difficulty in explaining some of the oil development with his "structure" map. The "low upfolds and shallow depressions" on the Shumway dome are probably not structural features but are either due to inaccuracies of the drillers or to erosion on top of the Stapleton oil zone.

In doing subsurface work where it is important to contour real structure in territory of low dip it is not advisable to use the drillers interpretations, but an attempt should be made to eliminate not only the actual mistakes in the logs, but also irregularities of depositional or erosional nature. Where this is not possible or where it is the intention to depict a sand or erosional surface rather than structure, the fact should be mentioned, that the contours do not show the real structure, but only approximate it.

THE MIDWAY LIMESTONE OF NORTHEAST TEXAS

WALLACE C. THOMPSON

INTRODUCTION

The Midway formation, the basal member of the Tertiary system in the southern United States, outcrops in a narrow belt along the Gulf Coastal Plain from Georgia to Rio Grande River. It is exposed with certain interruptions in a belt from 5 to 15 miles wide across the state of Texas. Beginning on the Rio Grande south of Eagle Pass it extends eastward to the vicinity of San Antonio, where the strike takes a northeasterly direction which it follows as far north as Hopkins County. Here the strike changes again and the belt continues eastward into Arkansas, concealed in the extreme eastern part of Texas by the overlapping Wilcox formation.

It is hardly possible in the space of one paper to discuss thoroughly all of the different phases of interest mentioned herein since any one of several subjects which are only briefly mentioned might well be treated in a special paper. We shall be chiefly concerned with the basal portion of the Midway in the area from southern Limestone County northeastward through Texas, (Plate I), omitting as far as possible discussion of details in any locality. The basal limestone of the Midway formation is the only recognizable horizon in a large part of east Texas and is therefore of particular interest to petroleum geologists.

THE NAVARRO-MIDWAY CONTACT

Between the Midway and the underlying Cretaceous is an unconformity or, rather, a disconformity, which is in evidence all along the contact in the United States. Few if any points of contact show a marked or noticeable change in sedimentation, but paleontologic investigations show that a complete change in life took place between the latest Cretaceous and the earliest Tertiary deposits.

In southwest Texas the contact is well defined. At certain localities in the Rio Grande country the Midway limestone

rests directly upon beds of the Escondido formation, the equivalent of the upper Navarro. Farther along the outcrop, especially in east Texas, the contact is more obscure since basal sandstone and shales are present between the limestone members and the underlying Navarro formation. These beds are soft and weather easily making the contact hard to distinguish. Kennedy mentions two places where the Navarro-Midway contact is exposed, the first on the bank of Brazos River one mile above the Milam County line in Falls County[1], the second several miles west of Elmo in Kaufman County[2]. In each case fossil evidence rather than a break in sedimentation is used to define the contact.

It is thought that the Midway sea advanced over a land of moderate relief or at least a topography devoid of any sharp features. The evidence at the contact suggests that the lower sands and shales of the Midway, which vary from 0-75 feet in thickness, filled in the depressions in this topography so that the limestone, which is younger, was deposited on a relatively flat surface. In some cases the thickening of the limestone may be due to its having been deposited in such depressions. The limestone sometimes rests directly upon Cretaceous rocks but is more often underlain by a varying thickness of Midway beds.

It seems very probable that a large part of the basal Midway was derived from the clay and sand of the Navarro upon which is was laid down. Naturally the contact of two such similar sets of beds is very hard to distinguish although it represents a great time interval.

THE MIDWAY LIMESTONE IN ITS BELT OF OUTCROP

While the basal part of the Midway formation may be traced for a great distance across the state there are numerous changes in its character to be noted at different localities.

From Falls County northward through Limestone County

[1] Kennedy, Wm. The Eocene Tertiary east of the Brazos River. Proc. Acad. Nat. Sci. Philadelphia, 1895 p. 145.

[2] Kennedy, Wm. A section from Terrell, Kaufman Co., to Sabine Pass on the Gulf of Mexico. Third Ann. Report Geog. Survey of Texas 1892 p. 49.

to the quarry west of Richland, in Navarro County, the limestone is fairly continuous and does not change in character materially. The outcrop is characterized by sharp cuestas capped by the limestone, which in this district consists of several irregularly stratified beds, light yellow to white in color, and aggregating 20 to 50 feet in thickness.

The thickness of the limestone increases locally south of the Mexia field. In several wells drilled in southern Limestone and northern Falls counties, as much as 200 feet of almost unbroken limestone is encountered[3]. This thickness evidently represents a local condition in sedimentation since at no other point, either north or south, is the limestone as thick as this. While faults are kown to exist in this area the structure has been worked with sufficient care to show that the thickening of the limestone is not due to repetition of beds.[4]

The following section measured at the Old Reunion Grounds south of Mexia, is characteristic of a large part of the Mexia district[5].

Section of Midway limestone south of Mexia, Texas

White fossiliferous limestone weathering into irregular blocks.	3 feet
Covered.	8 feet
White fossiliferous limestone, well stratified.	11 feet
Covered.	14 feet
Hard resistent, blue gray limestone.	5 feet

The limestone outcrops in the Mexia district in two parallel belts extending in a northeast-southwest direction, one through the Mexia field and the other to the west along the ridge which passes through the town of Tehuacana. These belts are separated in the Mexia field by a downthrown block or a graben the throw of which is about 400 feet.

Between Richland Creek and a point north of Kemp in Kaufman County, the limestone series is not seen. Other members of the Midway are present throughout this distance but the fossiliferous basal members do not appear. A concretionary bed of chert and cherty limestone crosses Trinity River about

[3] Three wells drilled by the Atlantic O. Prod. Co. namely the Steele in Falls Co., and the Garrett and Ainsworth in Limestone County, passed through a thickness of limestone from 150-200 ft.

[4] Whitehead, R. B. Personal communication.

[5] Measured by Willis Storm.

2 miles northwest of Bazette Crossing in Navarro County. This is the only hard bed that can be traced across the river and is considerably above the limestone stratigraphically.

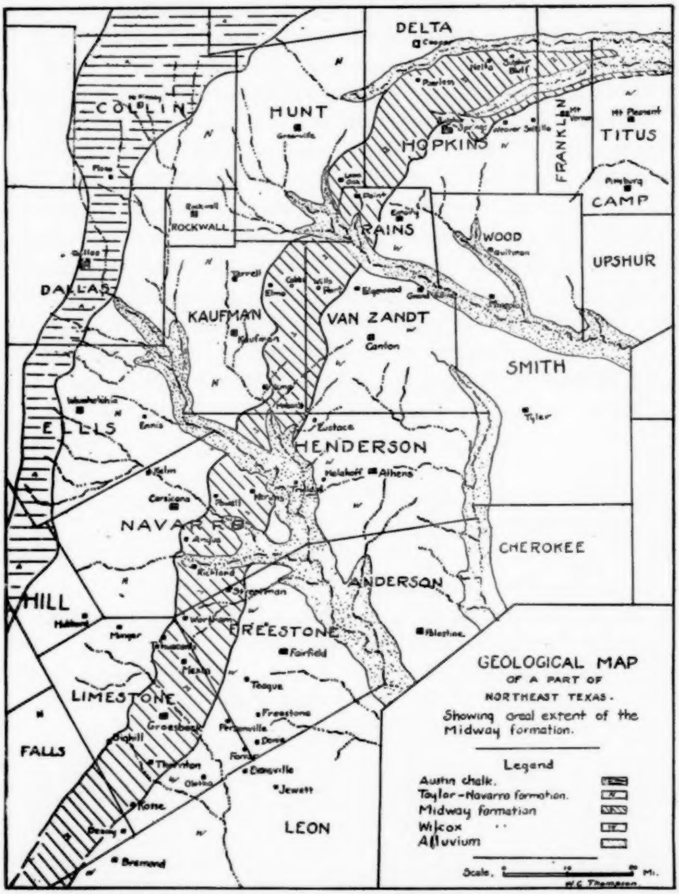


Plate 1. Geological Map of a part of Northeast Texas Showing areal extent of the Midway formation

The cause for the absence of the limestone in this district is not apparent since the upper series is not interrupted and

there is no evidence of thinning which would be responsible for the missing member. The disappearance of the limestone is probably due to several contributing conditions rather than to any one cause. Trinity River is an antecedent stream and in a large part of the area where the limestone is missing this river and tributary streams have reduced the land to low valleys and floodplains and may have eroded most of the limestone. The limestone member may also lense out or change character in this area as is the case in other areas. Aside from this, the geographic conditions during early Midway time might have been such that the limestone was deposited in a different position from its present apparent trend or even was never deposited. Such features as a land mass or, more likely in this area, an estuary might cause unfavorable conditions for the deposition of this series. It would seem that a combination of such conditions is responsible for the local absence of the basal limestone.

From southern Kaufman County northward to Sabine River the limestone outcrop is fairly continuous and is practically the same in general appearance as farther south. In this area a zone of limestone and calcareous sand and shale from 10 to 15 feet in thickness is usually present. The limestone beds are characterized by an abundance of fossils, chief among which are species of *Turritella* and certain forms of *Pecten*. The following section at Hiram in northeastern Kaufman County is typical of the area.

Section at Hiram, Kaufman County, Texas.

Hard fine grained limestone.	1 foot
Sandy shale.	10 feet
White fossiliferous limestone.	3-4 feet
Sand and calcareous shale.	40 feet

Boulder-like concretions, often several feet in diameter, composed of calcareous sandstone and shale.

In this region, as at Mexia, the outcrop of the limestone often occurs in parallel belts due to abnormal structural conditions. The Midway limestone has been of especial value as a key bed for geologic mapping in eastern Kaufman County. Much of the structure in this portion of the country, including such areas as Beckers Gin, College Mound, Chief, and Elmo

were mapped on the basis of these beds and will be tested for petroleum within the next few months.

From Kaufman County, this series extends into the extreme southern edge of Hunt County, where the outcrop ends in the bluffs above the south fork of Sabine River.

The next exposure is found on the highlands across Sabine River, near the Hunt and Rains county line but the appearance has changed greatly. Here, there is only one hard bed about three feet in thickness. This bed is granular in texture, and contains minute fossils, noticeable among which are sharks teeth, and small chert pebbles and grains of glauconite. About three miles northwest of the outcrop just described and parallel to it, is another exposure identical in lithologic character and without doubt the same bed. A good section may be seen at a rock quarry about four miles west of Lone Oak in Hunt County. At this quarry about fifteen feet of almost solid limestone is exposed. The variation in thickness is probably due both to lensing of the beds and to erosion.

The outcrops of this bed in essentially parallel belts at once suggest an abnormal structural feature. The exposures are not of sufficient extent to determine the structure in detail but a condition similar to that existing at Mexia, namely a faulted area, is probably present here. In this case the limestone at the quarry bears to the outcrop farther east the same relation that Tehuacana hill bears to the outcrops in the Mexia field. At Mexia there is definite evidence that a block fault or graben is present west of the field, but in this area structural conditions can only be assumed until some holes are drilled. The ridge upon which the limestone at the rock quarry outcrops, continues for some distance northeastward but the hard limestone disappears. In the area northwest of Lone Oak the hard bed is replaced by a soft sandy marl that appears only in deep ravines and roadside gullies. At many places large numbers of shark teeth have weathered from this bed.

This soft member may be traced with difficulty into Hopkins County, where it is present at a few localities near the villages of Peerless and Emblem, especially on the hills south

of Sulphur River. Its thickness rarely exceeds one foot.

A hard member of the basal Midway comes in again three miles northwest of Nelta in Hopkins County. This bed is from 18 inches to 2 feet thick and contains many fossils, and in general strongly resembles the limestone in Kaufman County. It is present in a relatively small area along a small tributary of South Sulphur Creek.

A lenticular limestone, somewhat similar in appearance to the beds at the Lone Oak quarry, outcrops for a short distance in the bluffs of South Sulphur Creek, north of the town of Sulphur Bluff but specimens of *Exogyra costata* and other Cretaceous fossils definitely place this outcrop in the Navarro. The Midway formation is concealed by the overlapping Wilcox from western Morris County eastward and is not definitely known to outcrop any farther east in Texas.

THE MIDWAY LIMESTONE EAST OF ITS BELT OF OUTCROP

As yet there are few data available that throw light upon the position and extent of the Midway limestone after it dips beneath younger beds, but there are strong suggestions that, as limestone, it is somewhat restricted in extent from east to west. Formations as old as the Woodbine sand have been identified in some of the salt domes of east Texas, but in each case the presence of Midway is doubtful. Powers[6] describes what he thinks is the equivalent of the Midway formation on the Butler Salt Dome in Freestone County but none of the characteristic basal limestone is present. Hopkins[7] questions the presence of Midway beds on the Palestine and Keechi domes in Anderson County. Certainly the limestone as it exists at the outcrop would be recognizable if present in these domes.

A change is also indicated by the absence of limestone in wells, east of the outcrops, where it should appear. The hard beds probably change character to the east and are present as a sandstone or shale in wells that pass through them. Too

---

[6] Powers, Sidney. The Butler Salt Dome, Freestone Co., Texas. Amer. Journal of Sci. Vol. 49 Feb. 1920 pages 133-136.

[7] Hopkins, O. B. The Palestine Salt Dome Anderson Co., Texas. U. S. G. S. Bulletin 661 1917, pp. 259.

Plate II. Midway Limestone on the Navasota River south of Mexia. Typical exposure showing irregular bedding and honeycombed character.

few well records are available thus far to prove this point, especially with reference to the greater part of east Texas, but present evidence suggests that the limestone was deposited in a rather narrow belt more or less closely associated with the old shore line.

UPPER BEDS OF THE MIDWAY

Above the basal limestone is a series of shales and concretionary beds which make up the greater part of the formation. The shales are yellow and blue in color and usually well stratified. The concretions are usually black on a fresh surface weathering to yellow or white. These concretions sometimes form a zone which may be traced over a large area, but as a rule their vertical extent is so great that they cannot be used to determine structure. Typical exposures of the concretionary beds may be seen northeast of Kerens in Navarro County, southeast of Kemp in Kaufman County and also in the Wills Point area. This upper series is sometimes differentiated locally, such as the Kemp Clays and the Basal or Wills Point Clays.

The thickness of the Midway formation as a whole is variable and there seem to be no definite figures accepted for the thickness at any given locality. Deussen[8] gives the thickness of the formation as 250-500 feet, while Stephenson[9] merely assigns a thickness of 200 feet. With the changes in dip and other structural features accurate measurement at any point is difficult. However, considering the width of outcrop with the average dip and also the meagre data from well records it seems that the Midway formation is at least 500 feet thick in northeast Texas.

MIDWAY-WILCOX CONTACT

In general, the contact between the Midway and Wilcox formations is characterized by a break in topography. The upper Midway is characterized by open prairie land with no timber except along the larger streams. The beginning of the Wilcox is usually marked by sandy land and heavy growth

---

[8] Deussen, Alexander. U. S. Geol. Survey. Water Supply Paper 335 p. 29.

[9] Stephenson, L. W. U. S. Geol. Survey Prof. Paper 90 p. 156.

of timber. Not infrequently the contact is marked by a low ridge of Wilcox sandstone.

ECONOMIC IMPORTANCE OF THE MIDWAY LIMESTONE

Aside from its importance from a geologic standpoint, the Midway limestone is of considerable economic importance. Since it is the only hard formation in a rather wide belt it has been used extensively as a building material, especially as crushed rock and in concrete work. Quarries are situated at Tehuacana, Richland, Beckers Gin, Lone Oak and other places from which the limestone is taken and used for road ballast and crushed rock. At certain localities, notably in the Abel Springs and McCoy area in northern Kaufman County the limestone has been burned to produce lime for mortar. It was important in this respect in the early days. Wherever the basal series of the Midway is relatively close to the surface it is usually important as a water horizon. In a large area embracing the northeastern part of Kaufman County and the northwestern part of Van Zandt County the limestone beds carry water and are usually the chief scource of domestic supply. Sometimes the water is unfit for drinking purposes on account of its high lime content. The limestone is also an important water horizon in the Mexia district. Wherever the limestone is encountered water is present but the flow is exceptionally strong in wells located in the faulted zone west of the field. The town of Tehuacana is supplied with water from a well in this formation.

ORGANIC MATERIAL OF CARBONACEOUS SHALES

By Colin C. Rae

Considering the important progress made during the past twenty years in the methods of structural mapping and study of stratigraphy, very little advancement has been made in the identification of the organic material of carbonaceous shales or possibly limestones, of which knowledge is essential in location of prospective oil territory or extensions of proven areas.

Due consideration is given, where possible, to the amount and character of the carbonaceous or bituminous strata, but usually the dark color indicating carbonaceous material is the extent of field study. However, many dark shales often have carbonaceous coaly material, rather than the organic "kerogen," the source of petroleum. When the organic substances have been sufficiently altered to produce bituminous material, the work of the geologist is simplified, but in many cases, the shales will contain organic material rather than bituminous.

Thus it is difficult at the present time to state definitely whether the organic material in the carbonaceous shales is the proper type to produce petroleum. If some definite microscopic, chemical or physical tests could be established to indicate the identity of the organic material, which is the source of oil, then future geological field work on structure or stratigraphy, would be supplemented where possible, by tests of the shales closely associated with possible oil sands.

Sufficient work has been done to indicate that the organic material producing oil, called by some authors "kerogen" is a much varying material under microscopic study consisting of a coagulated, amorphous, organic ground mass, in which various types of fossil material, spores, seeds algae, etc., are embedded. Sometimes no identifiable remains are found. A brief resume of the microscopic work and possible identity of the unknown, amorphous, organic ground mass will probably give the foundation for more detailed work.

REVIEW OF MICROSCOPIC WORK ON CARBONACEOUS OR ORGANIC SHALES

In the microscopic study of the original organic material in the shales, some investigators used acids and alkalis, which might alter some organic constituents of the slides although giving a clearer view of fossil matter. It seems that the first studies should be made with great care to retain unaltered shale without use of possible solvents, heat or pressure.

Reinhart Thiessen of the Bureau of Mines did considerable microscopic work on the Devonian and other shales of Kentucky and Indiana. After treatment by hydrochloric acid, he found spores to be the chief recognizable plant remains, hence assigned the probable origin of oil to the spores. Spores are disc shaped plant material from which low forms of plant life, which do not have seeds, reproduce themselves. It is probable that Devonian ferns may have been the source of these spores.

However it seems that Thiessen did not sufficiently consider certain factors in his slides. The photographs show light colored spores imbedded in a much darker colored matrix. It is usual in any particular shale that the darker, black colored portion will have the greatest amount of organic material. Thiessen was unable to identify the darker, richer portion of the matrix. It presented no recognizable plant remains, but seemed tò be a homogeneous mass adapting itself to the spaces between the spore material. The possible origin and character of this unknown, rich dark colored material in the slides and the organic material dissolved by acids in digesting process is what this paper will attempt to identify.

Marcus Goldman of U. S. Geological Survey in his preliminary report on the Bend series of Texas mentions the fact that the dark, rich organic matter of the richer shales and limes often has a flocculent, amorphus appearance with no recognizable plant forms.

The late Dr. C. A. Davis, of the U. S. Bureau of Mines, in his personal notes made mention of the jelly-like mass of organic substance in which the plant forms of Eocene oil shales were embedded. He also noted in some beds a marvelously complex delicate plant growth of felted character probably

similar to that described by Zalesky from the Silurian of northwestern Russia.

Prof. R. D. George and others have done microscopic work on the oil shales of Colorado, Wyoming and Utah. The brown shales afforded much study of seeds, stems, cuticle, leaves, spores etc. These sections are first digested with alkali, then treated in a hydrofluoric bath for two weeks, and lastly cleaned by weak sulphuric acid. This treatment undoubtedly dissolves much of the jelly-like amorphous flocculent organic material. However the very rich lustrous black oil shales, even after treatment, rarely afford sections in which even minute plant remains can be studied. Solution tests show no bituminous matter. Thus the richest black Colorado shales, similarly to the Devonian shales and to the Bend series, show a very rich unknown dark colored organic substance in which no recognizable plant remains can be identified.

This seems to be a similar characteristic of various shales of different ages. When one considers what animal and vegetable material, the ordinary river water would show under a high powered microscope, for it would undoubtedly look like vegetal debris, and some water, instead of water, and some vegetal material, it seems very strange that if it is the plant material itself or remains of marine life from which the oil originates in these various carbonaceous shales, the richer material has little of plant remains which a high powered microscope can identify. It does not seem probable that the forms can be preserved in the poorer material, and then be completely degraded and cut into unrecognizable shreds in many richer shales. We will next consider the possible identity of this unknown organic material.

IDENTITY OF UNKNOWN ORGANIC MATERIAL

The common distribution of plant remains through many formations which are not productive of petroleum, the concentration of petroleum hydrocarbons in extensive deposits in some localities, and many other factors, such as the unknown amorphous, flocculent material in the microscopic slides of carbonaceous shales, seem to indicate the existence of an intermediate organic hydrocarbon between the organic com-

pounds of the plant or animal liffe and the petroleum hydrocarbons, and much evidence points t othe humic acids or associated organic compounds, which are probably collected by surface waters and concentrated in certain areas by means of precipitation by electrolytes, such as would be contained in sea water or possibly in various inland seas or lakes.

Considering various types of plant life, the fruits and seeds have the principal portion of mineral matter such as phosphorus and much more nitrogen, while the bulk of material growth is chiefly composed chemically of carbon, hydrogen, oxygen and some nitrogen. When the plant or animal dies, the chief decomposition products are water, carbon dioxide, and ammonia. However the action of rains and surface waters tends to accumulate the decomposed matter in form of ulmohumic acids and ammonia before the organic compound is completely broken up. Some of this material is absorbed by the soils resulting in humus enrichments. Much of it is collected by surface waters and concentrated in the large rivers on the way to the sea.

It is difficult to give the exact chemical formula for the ulmohumic acids, as organic chemistry is still in process of development. Prominent chemists have shown that the humus acid group can become colloids, and as such are easily precipitated by sodium chloride (common salt), calcium sulphate (gypsum), iron sulphate and other electrolytes.

The difference between a colloidal solution, and a suspended solution is that the colloidal solution is absolutely uniform, and has the power of dialysis, which means diffusion through membranes such as parchment, pig bladder, collodian soaked filter paper, etc. It is now the opinion of chemists that the colloid state is of great assistance to chemical actions and is a universal possible state of matter, meaning that under certain conditions, all substances can become colloids. Gold and silver colloids are two extreme cases, while india ink, skim milk, various dyes, etc., are more practical examples. A good example of the various states of any one element would be the four stages of sulphur. First the large crystals of sulphur, secondly, the finer minute crystals called flowers of

sulphur, thirdly, a yellow colloidal solution of sulphur in benzol, fourthly, a molecular state of sulphur in a solution of carbon bi-sulphide.

The small particles in a colloidal solution have an electrical charge. Certain chemical colloidal elements are positive, others are negative. Consequently when the solution varies in temperature, alkalinity and acidity, the colloidal solution is affected. Hence the amount of dissolved humus acids in various river waters would vary with the alkalinity, temperatures and salts present in the waters, which would depend upon the type of drainage area, the climate and humidity.

The effect of alkalis and acids upon colloids is subject to variation. This action must not be confused with the action of electrolytes in precipitation. Sometimes negatively charged colloids are precipitated by a slight amount of negative acid colloids such as humus, but on addition of an excess, would not have been precipitated. Certain river waters have much negative colloidal silica with the humus, but it has not been definitely explained why it does occur. It is probable that the excess of colloidal humus has an effect upon the colloidal silica.

The amount of dissolved material in stream waters is a variable factor, but in most large rivers it amounts to millions of tons yearly. For example, the streams of the small drainage area of England and Wales carry eight million tons of dissolved material yearly. The following are a few analyses of some river waters showing the percentage of humus in this dissolved material carried by the rivers, and shows the effect of drainage area as well as humidity:

Anaylsis of river waters showing percent of humus in dissolved material.

James River	4.14	
Nile	10.36	
Hudson	11.42	
Thames	12.10	
Amazon	15.03	
Lough Neigh (Ireland)	16.40	(boggy)
Plata	49.59	
Negro	53.89	
Uruguay	59.90	

These analyses show that in some large rivers, many hun-

dred thousand tons of dissolved humus acids are carried to the sea each year.

When the rivers or streams reach the ocean or various inland lakes or seas, the action of the electrolytes such as gypsum, common salt, iron salts, etc., causes a precipitation of the humus material. Simultaneously, the water decreases its velocity and much sediment and material are dropped. The waters of large rivers do not immediately mix with the sea water, nor drop all sediment, but it is a gradual, assorting action which may take place for many miles. The precipitated organic material would be in a jelly-like, amorphous form, which would collect or hold various plant and marine material in the river or sea water, also much mud and sediment, sinking to bottom and becoming part of the shales or possibly limes which are being deposited in that area.

The microscopic work on various carbonaceous shales has shown that there is an unknown, jelly-like, amorphous, rich organic material. This material has the character and type of a precipitated organic compound of the humus acid group. It is incorporated in various strata, probably chiefly in shales, and in limes to much less extent. Later by means of stress, pressure, heat and other factors such as catalyzers influencing the chemical change of the organic material into petroleum, the organic compound may be converted into oil. In the absence of necessary heat, pressure, etc., it may retain its jelly-like, organic composition, and be constituent of the so-called oil shale.

Having correlated the unknown, dark, organic material in the shales with the type of material collected by streams and later precipitated and incorporated into shales and limes, the present day evidence of the association of the humus organic compounds with oil, particularly in presence of sea or inland lake waters will be considered.

PRESENT DAY OCCURRENCES OF PETROLEUM ASSOCIATED WITH ULMOHUMIC ACIDS

Binny in the London Institute of Mining Engineers in 1912 made mention of the fact that evidence of petroleum was collected from a peat or swampy bog at the time of incoming

tides. He could not explain this action, and it may be that slight amounts of petroleum are formed from the precipitated organic compounds in presence of proper catalyzers and sea water. Haseman in the American Association of Petroleum Geologists, 1921, reports certain occurrences of asphalt in very recent formations, where fresh water swamps existed adjacent to the sea, in Florida and Georgia. From the evidence, he concluded that the asphalt had been formed from the humus acid group, assisted by the presence of sea water and probably electrolytes. Haseman's paper was an important application of the humus acid precipitate theory, which was outlined by the author of thhe paper in a "thesis" for the University of California in 1912. While Haseman made definite statements concernnig the origin of asphalt from the humus, he did not note the importance of river waters in collecting and concentrating the organic compounds.

There are a few points in the Gulf of Mexico where the heavy mud stirred to depth of a few feet will give off fine globules of oil. While there is a possibility of seepage in that area, still it checks the foregoing evidence so closely that it is worth mentioning. At first the oil bubbles were assigned to the diatoms or remains of marine life, but Dr. Harold Turner of John Hopkins University made a close study of the muds, and while diatoms were present in some barren muds, there were very few in the mud producing oil globules. It was described as black mud mixed with unidentifiable amorphous organic material and fine grains of silica. In this connection, it might be well to mention that sometimes river waters carry 20 to 50 percent colloidal silica in solution, which likewise would be precipitated by electrolytes at the same time as humus acids.

In the dead sea, oil has been distilled from the heavy black muds accumulating in the bottom, where the organic material from the stream waters could have been precipitated by the sea. In the Mediteranean, petroleum has been distilled from the heavy carbonaceous muds but the type of organic material producing it has not been studied in detail.

Bertrand and Renault in an excellent paper, reported pe-

troleum distilled from organic material consisting of algal remains buried in a humic acid jelly. They did not differentiate the humic ground mass from the fossil content. Later work by Thiessen and Jeffrey has indicated that the reported algal remains may be spore material.

The application of the identity of the ground mass as ulmohumic acid to the Eocene shales in Colorado, Utah and Wyoming is interesting. The presence of gypsum seams, iron minerals, salts, and oölitic lime deposits similar to those being formed today on shores of Salt Lake shows conditions for the sufficient concentration of lake waters, which would cause precipitation of the organic material. The vegetation at that time shows a warmer climate than at the present day, probably favoring development of plant life and humus.

If the unknown organic ground mass of petroliferous shales was an ulmohumic jelly caused by precipitation of colloidal humus by salt, gypsum, iron sulphate, or other electrolytes, the presence of one or several of these should be indicated by minerals present in the shales. Since the marine evidence of most shales shows saline conditions, and in other shales the presence of pyrite,—probably iron sulphate reduced by organic material to pyrite,—gypsum, and other materials, is common, the evidence seems to correlate the precipitation theory.

It may be possible in field work to test the brown or dark carbonaceous strata for the type of organic matter capable of producing petroleum. The color is not always a clear indication, since it may be carbonaceous rather than the ulmohumic ground mass with vegetal material such as spores. etc. Further research work will probably develop better tests along lines indicated later in this paper, but the vest pocket alcohol blow torch used by Dean Winchester with small test tube to indicate by condensation of oil globules in the glass tube, the possible petroliferous type of the formation, may prove to be valuable.

SUMMARY

Microscopic work on shales associated with oil deposits has shown the presence of an unknown, rich, dark, organic, ulmohumic, ground mass with varying, identifiable organic remains, which are sometimes missing entirely. Present day

evidence shows that asphalt can be formed from the ulmohumic acid precipitates in the presence of sea water and electrolytes. Rivers and streams act as the concentrating agents for millions of tons of organic material, which are later incorporated into marine or inland lake deposits. By subsequent pressure, heat, or catalytic agents, the organic material is converted into petroleum probably varying with the type of humic precipitate and perhaps in part with its fossil content and with the rate of geochemical change caused by pressure, heat, presence of catalytic agents and filtration by product.

Unfortunately, no detailed microchemical work has yet been done upon the shales using various solvents, pressures and heat gradually to note which substances disappear in the production of the various petroleum products, and to differentiate accurately between the ulmohumic groundmass and the varying types of fossil contents. If definite knowledge could be obtained as to whether the source of petroleum is the ulmohumic ground mass or certain identifiable fossil material, or both, and that certain tests, probably microchemical, would show the value of various types of carbonaceous shales as the source of petroleum, it would undoubtedly be very valuable in the location and search for new oil areas.

The research work to establish and identify the organic materials would require many months of careful microchemical work. Besides being important to future geological work, the research may show the process of transmission of certain organic substances into petroleum. David White, Chief Geologist of the United States Geological Survey, is undoubtedly the most capable man to direct and manage the research work, and it seems that the expenditure of money to investigate thoroughly the source of oil from shales associated with oil deposits, would be well justified.

A PRELIMINARY STUDY ON THE RECOVERY OF OIL BY SINKING SHAFTS AND DRIVING GALLERIES

LOUIS FRANKLIN

INTRODUCTION

It is generally accepted that the compressed and absorbed gases in an oil sand are the chief expulsive energies in the sand, the viscosity of the oil, the nature of the pores, and friction of the oil passing through the pores constituting the chief restraining forces.

When an equilibrium is finally established in a sand, between these expulsive and restraining forces, it is estimated that 40 to 60 percent of the oil is retained in the ground; some estimates of this unrecovered portion are as high as 90 percent.[1] The vacuum pump, air lift pump, swabbing, bailing, agitation devices, all have failed, more or less, to recover entirely this remaining portion of oil. The relative failure of these devices combined with the increased demand for oil has resulted in an attempt to mine the 40 to 60 percent oil remnant by sinking shafts and driving galleries into the oil sand.

The idea of digging shafts and driving tunnels to obtain oil is not a new one. Pits were dug for oil throughout the ages and was the common practice of the American Indian. In the nineteenth century shafts and galleries were worked on a commercial scale in Pechelbronn, Alsace, but were abandoned on account of the large quantities of gas that were encountered. Over thirty-five years ago the Union Oil Company of California[2] had dug twenty-six tunnels to reach an oil formation on the southern flanks of Sulphur Mountain where conditions are favorable for such methods. These tunnels were intended originally for development purposes, but when completed were used as a source of production. The most successful attempt to mine oil by shafts and galleries on a

[1] Lewis, J. O., Methods of increasing the recovery of oil from sands. Bull. 148, Bureau of Mines, 1917, p. 26.
[2] Union Oil Co. of California. Bull. No. 6. Aug. 1921, p. 5.

Louis Franklin, 1028 45th St., Milwaukee, Wis.

modern scale was in Pechelbronn, Alsace, where the method had been previously tried and abandoned in the 19th century. The war demand for oil was so great that in 1916 shafts were again sunk in the mines of Pechelbronn and oil was drained by driving galleries and washed from the sands.[3] This last attempt proved very successful.

PHYSICAL FEASIBILITY OF MINING PETROLEUM BY SHAFTS AND GALLERIES

The Establishment of an Equilibrium in an Oil Sand

Two important changes take place in the oil sand when it is tapped. First, the gas pressure decreases over the entire sand; second, the diminishing gas pressure permits some of the gas absorbed in the oil to bubble out and press its way through the pores of the sand. This bubbling or "fizzing" action spreads over the entire sand, increases in vigor with the decline in compressed gas pressure, and sets the oil in motion. In time, the absorbed gas escaping from the oil does not flow out of the sand into the well but fills the pores of the upper layer of the sand, which have drained first, and instead of forcing the oil out of the lower pores, due to insufficient pressure, prevents the remaining absorbed gas from escaping, and in this way stops the "fizzing" action in the sand. The movement of oil through the sand ceases when the bubbling activity of the gas stops and an equilibrium is established. The pores in the upper parts of the sand remain filled with gases and the pores in the lower parts of the sand stay filled with isolated drops of oil separated by pores and gas bubbles. Thus the absorbed gases which in the early history of the sand set the oil in motion, in a later stage prevent oil movement.

Failure of Surface Devices to Destroy Equilibrium

The well at this stage yields very little oil, and recovery devices are tried. A vacuum pump applied to the well has little effect upon the oil content of the sand. By creating lower air pressure in the well the gases in the upper layers of the sand will be set in motion and may sufficiently decrease

[3] De Chambrier, Paul, Journal of the Institution of Petroleum Technologists. Vol. 7, No. 27, July 1921, p. 178.

in pressure to create some "fizzing" action in the lower parts of the sand, but insufficient to cause much oil flow.

Greater recovery of the oil left in the sand is obtained by forcing compressed air into the well.[4] The compressed air has a double effect upon the equilibrium that has been established between the oil and gas in the sand. First, the pressure in the sand is increased; and second, the bubbling action will be rejuvenated to a greater degree than by the vacuum pump. This dual effect of the compressed air increases the oil recovery. At its best this method has its mechanical and physical limitations. The air pressure is insufficient to overcome completely the friction caused by the viscosity of the oil and it cannot overcome entirely the capillarity in the pores.[5] The compressed air method which is best applied to a uniform sand with connected large pores, is least effective in a variable sand, and "should be used as a last resort when the ordinary methods are no longer effective."[6]

Bailing, swabbing, and agitating devices are convenient at times but have both mechanical and cost limitations.

How Shafts and Galleries Recover all the Oil

Surface devices fail to destroy the equilibrium between the absorbed gas and the immobile gas in the upper pore spaces. This balance is completely destroyed and direct access to the oil is possible when a shaft is sunk to the bottom of the sand and galleries driven into the sand at convenient distances apart. When a gallery is driven into the sand the immobile gas in the upper parts of the sand is removed, the absorbed gases are again able to escape, the isolated drops of oil unite and seep into the galleries, from where the oil flows in channels constructed in the floors of the mine into a collecting pool at the bottom of the shaft and then is pumped to the surface.

The oil-soaked and oil-covered sand that is brought to the surface by tunneling adds another large percentage to the oil

[4] Arnold, Ralph and Garfias, V. R., Methods of Oil Recovery in California, Tech. Paper 70, U. S. Bureau of Mines, p. 14.
[5] Arnold and Garfias, loc. cit. p. 21.
[6] Arnold and Garfias, loc. sit. p. 16

recovered by seepage and mining. The oil from this sand is recovered by washing with hot water. The importance and magnitude of the quantity of oil that can be recovered by washing oil sands cannot be overestimated. Elliott[7] states that in California, "From the data collected, it is estimated that 2,359,100 barrels of oil valued at more than $3,500,000 could be obtained from the sand piles about producing wells and from out-crops in the vicinity of the fields." What immense quantities of oil could then be recovered by actually mining the oil soaked sands?

Mining of oil by shafts and galleries physically practicable.

That the mining of oil by shafts and galleries is physically practicable has been demonstrated in the mines of Pechelbronn, Alsace. While the physical conditions in Pechelbronn are very favorable for mining operations there are numerous places in the United States and in the world, where similar or equally favorable conditions exist. The presence of water formations makes mining operations more difficult but this is easily overcome by proper timbering. The greatest difficulties encountered in the operations at Pechelbronn are those of gas and fire. By a very thorough and good ventilating system and the proper kind of working methods the danger of gas is almost entirely eliminated. The danger of fire is prevented by very careful operations. Instead of using a pick ax, which when struck against a rock will give off sparks, the compressed air drill is used. The latter does not give off sparks and facilitates the work. A great deal of precaution is taken in the lighting, working and equipment operations of the mine. Special devices and fire proof rooms are put in the mine for safety. There is little doubt that with improved mining methods the mining of oil can be made as safe as any other kind of mining.

Results of Mining Oil by Shafts and Galleries.

The outstanding result of the Pechelbronn mines is the fact that oil was obtained from sands, which were believed to be

[7] Elliott, A. R., Recoverable Oil By-product Sands and Outcrops, Reports of Investigations, Bureau of Mines, Nov. 1920. Serial No. 2182.

exhausted, and in two to five times the quantity that had previously been produced by the wells. This large recovery came from the richest parts of the beds, and if the leaner parts of the sand had been worked the ultimate total recovery would would have been still greater.

ECONOMIC CONSIDERATIONS.

The mining of oil by sinking shafts and driving galleries is economically feasible. The cost per barrel of oil produced by wells based on the cost of drilling and operating a well is not commensurate with the cost of oil produced by sinking a shaft and operating a mine. The Federal Trade Commission in its Report on The Pacific Coast Petroleum Industry found that "The chief factor in cost seems to be the volume of production per well," The more productive wells show the lower average cost per barrel.

Chambrier[8] calculates that in the United States it would take "116 productive borings in a new district, in order to obtain a quantity of oil equal to that produced by underground workings of abandoned oil fields." Chambrier bases his calculations on the fact that in five years the "galleries" at Pechelbronn will produce 150,000 tons of oil and that during a period of ten to fifteen years the average American well will produce about 1300 tons of oil; thus 150,000 divided by 1,300 equals 115.4 Mr. Chambrier's estimate of American production per well may be rather low but the fact still remains that, whereas one shaft will produce at least two times as much oil from a sand that has been exhausted by wells, it takes many wells to produce an equal quantity from a new sand. Moreover, whereas immense sums of money are spent in wildcatting, an oil mine is developed where oil is known to be present. Considering therefore, the quantity of oil that can be recovered by the shaft and gallery method compared to the number of wells that would have to be drilled to yield an equal quantity of oil and the wildcatting expense that is avoided, an oil mine from 500 to 800 feet deep is financially possible.

There are, in the United States, many shallow oil pools

[8] De Chambrier, Paul, loc. cit. p. 188.

exhausted or nearing exhaustion whose life could be prolonged many years and production greatly increased by the development of oil mines. The development of oil mines in the United States would increase the oil reserve at least 50 percent, and large quantities of oil valued at millions of dollars would be added to the petroleum industry.

CONCLUSION.

The subject as presented in this paper is preliminary and introductory. The writer has purposely omitted numerous problems for more exhaustive treatment in the future. Nothing has been said of the quality of the oil obtained from oil mine workings or the technique of mining and washing of oil sands. These problems can be solved and it is merely a question of time when large quantities of oil will be recovered by sinking shafts and driving galleries.

EDITORIAL

At the last annual meeting of the Association, held in Oklahoma City, provision was made for holding mid-yearly meetings in localities situated outside the Mid-Continent region. A cordial invitation has been received from the Rocky Mountain membership to meet with them in Denver in October, which after mature deliberation, the Executive Committee has decided to accept. The date set for the meeting is October 26, 27, and 28; announcement of further particulars will be made later.

In the past the geographic distribution of the membership has been the controlling factor in selecting a place for the annual meeting. Although oil geologists are ordinarily a migratory group, the fact remains that a majority of the members of the Association have their residence in the Mid-Continent and there is little prospect of a change in this situation within the near future. The concensus of opinion at Oklahoma City was that the annual business meetings should continue to be held at points most accessible to the majority of the members, and that the activities of the Association should be carried, through mid-yearly meetings, to the several important centers of geological activity outside the Mid-Continent.

The advisability of holding meetings distant from the large body of the membership has been widely discussed during the past several years and has always had many supporters. In the Rocky Mountains; in California; in the states east of the Mississippi; and in New York and Washington, there are important contingents of oil geologists, all interested in Association affairs, though many are prevented by the long distance from attending meetings in the Mid-Continent. The Association owes a duty to these men to hold meetings, occasionally at least, at points near enough for them to attend, particularly where any considerable group of members are within reach of a recognized headquarters, as is the case in Denver.

It is hoped that this will be the first of a series of regional meetings although the holding of similar meetings will no doubt depend largely upon the success of the present venture. Those who are acquainted with the able group of geologists resident in and around Denver will readily concede that the meeting will be a success in so far as the efforts of the local men can make it such; it remains to be seen how successfully their efforts will be seconded by the attendance and contribution of papers from the general membership.

The date of the meeting has been set for October 26-28th inclusive, in order to insure a large attendance of the geologists working in the Rocky Mountain region. The western field season will then be near its end; there will be no Osage sale during October; field operations will be at a low ebb owing to the present necessity of curtailing drilling in the Mid-Continent fields; and these several factors should make it possible

for many busy geologists to attend whose duties would not otherwise permit.

The Executive Committee makes an urgent appeal to the general membership to attend the Denver meeting. A thoroughly enjoyable visit is in prospect. Papers on subjects of general geologic interest are solicited for the program. This is a purely technical session,—no association business will be transacted, and it is hoped that there will be a liberal contribution of papers, all of which will later be published in the Bulletin.

W. E. WRATHER.

GEOLOGICAL NOTES

WILDCAT OIL EXPLORATION IN SOUTH-CENTRAL ARKANSAS

Of the many wells that have been drilled in south-central Arkansas for oil several apparently stopped short of the sand that yields the oil at El Dorado in Union County, and the greater number did not reach the sand that yields oil in the Haynesville field, in Claiborne Parish, La. Furthermore, practically all drilling has been done with rotary tools, a method which not only yields inaccurate records of the formation penetrated but which also frequently prevents the recognition and testing of oil sands that may be drilled through.

Several sands in northern Louisiana, below the Nacatoch have produced much more oil than the Nacatoch, and in some of the fields the Nacatoch is practically barren, in spite of the immense volume of oil in the underlying sands. The deepest formation in this region that now seems worth testing is estimated to lie 4,000 or 5,000 feet below the surface and may be below profitable drilling depth. This formation is the Trinity, which in Pike and Sevier counties, Ark., contains asphalt deposits that represent the meager remains of what were once rather large bodies of oil.

Although the character of the formation in southern Arkansas may require the use of the rotary drill, operators should realize its shortcomings and employ methods that will insure, so far as possible, detection of showings of oil and gas. Cores should be cut from all beds penetrated that yield showings and particularly from a sand near the base of the Midway formation and from sands in the Nacatoch, Marlbrook, Browntown, Blossom, Eagle Ford, Woodbine, and Trinity formations, whether or not oil showings are observed in the sludge.

The ages, relative positions, and thickness of the formations encountered in drilling in south-central Arkansas must be determined if the search for oil is to be carried out effectively and economically. These determinations are difficult because of the similarity of the beds of the several formations, and can be made precise only with the aid of fossils. The approximate boundaries of the larger units, however, may be determined from the character of the beds as shown by well records. The following descriptions of formations encountered by drillers in Union County, Ark., are the result of a detailed study of many well records. Inaccuracies in the well records may have caused like inaccuracies in the interpretation of the stratigraphy.

Probably all the rocks that cover the surface of Union County belong to the Claiborne group of the Eocene series of the Tertiary system, which in this general region is divided into two formations, the Yegua above and the St. Maurice below.

Yegua (?) formation.—Recent determinations of fossil plants by E. W. Berry indicate that the Yegua (?) formation is probably present in Union County, and that it comprises the surface beds over most of the

county. The beds that are probably to be assigned to the Yegua ("Cockfield") formation are recorded in well records as alternating layers of sand and gumbo, some shale and calcareous material ("boulders" and "rocks") and a little lignite. They may be distinguished from the underlying beds by their dominant sandiness. These beds probably attain a maximum of slightly more than 450 feet in the southeastern part of the county.

St. Maurice formation.—The strata in this area which are here identified as the St. Maurice formation are commonly recorded in drillers' logs as layers of shale and gumbo with many "boulders" and "rocks" and some sandy material. The St. Maurice is much freer from sand than the formation above and below it. It probably ranges in thickness from 90 feet in the northwest corner of the county to about 200 feet in the southeastern part.

Wilcox formation.—The Wilcox formation is generally shown in logs as thick alternating layers of sand, sandy gumbo, and shale, with some zones marked by "rocks" and "boulders," although subordinate amounts of gravel and lignite are occasionally noted. This formation can be recognized by an upper sandy group and a lower shaly group which contains less sand. Its thickness averages about 600 feet throughout Union County but increases slightly toward the east.

Formations similar in composition to the Wilcox have yielded small quantities of oil in Louisiana and Texas, and the expectation that some oil may be obtained from this formation in restricted areas is not unreasonable. A careful watch should therefore be kept for indications of oil or gas while wells are penetrating these beds.

Midway formation.—The beds referred to the Midway formation are recorded by the drillers as "bouders," "rocks," and layers of sand, gumbo, and shale, with more or less chalk, limestone, and gypsum. Recent microscopic studies of cuttings from wells in the El Dorado field by James Gilluly, of the U. S. Geological Survey, have shown these beds to include some lignite. This occurrence of carbonaceous material in the Midway, although by no means widespread, is nevertheless not unusual. This formation is characterized throughout by its relative hardness.

The greatest known thickness of the Midway at its outcrop is about 260 feet,[1] but this mesurement was taken near the shore line of the embayment in which the formation was deposited. The character of the strata penetrated indicates that the formation probably attains a maximum thickness of slightly more than 500 feet in Union County.

Many wells drilled in south-central Arkansas have obtained showings of oil or gas or flows of water in a sandy bed near the base of this formation. At only a few wells, however have tests been made to ascertain

[1]Kennedy, William, A section from Terrell, Kaufman County, to Sabine Pass on the Gulf of Mexico: Texas Geol. Survey. Third Ann. Rept., p. 49, 1892.

the true value of these showings. Especially in the El Dorado field has this bed remained untested.

Arkadelphia clay.—The Arkadelphia clay of the Cpper Cretaceous or Gulf series is in general easily recognized by its thickness and its freedom from sand. The strata recorded are mainly shale and gumbo, which are generally accompanied by many layers of "boulders," "rocks," chalk, limestone, and gypsum, and in a few wells layers of sandy shale. A very noticeable group of chalky or calcareous beds makes up the lower 175 or 200 feet of the Arkadelphia. The thickness of this formation averages about 550 feet in the western part of Union County and increases eastward, possibly to as much as 600 feet near the eastern boundary.

Nacatoch sand.—The drillers' log record the Nacatoch sand as beds of hard sand, shale and limestone with many layers of "rocks," "boulders," and "pyrite" and some gumbo and chalky material. The upper part is commonly hard and sandy; the lower varies from slightly calcareous shale to hard limestone, although it usually includes thin sandy layers. The thickness ranges from 150 to 200 feet.

The Nacatoch has been identified by its fossils as the producing sand at El Dorado.[2] The oil there is obtained from three or four discontinuous layers of sandstone in the upper 50 feet of the formation.

Marlbrook marl.—The Marlbrook marl is recorded as shale, chalk, "boulders," limestone, and lesser amounts of gumbo, "rocks," and "pyrite," and some sandy shale. This formation consists typically of shale and varying amounts of calcareous material. It ranges in thickness from about 300 to nearly 350 feet.

A group of sandy shales between 400 and 500 feet below the top of the Nacatoch usually yields water wherever it is penetrated. The beds at this horizon may contain oil or gas where the structure is favorable.

Annona tongue of the Austin chalk (?).—Fossils obtained from one of the wells[3] indicate the Marlbrook age of strata at least 250 feet below the base of the Nacatoch sand, and as no marked change in the character of the sediments down to the Brownstone marl is recorded, the Annona tongue or Austin chalk may be absent here. However, as this tongue, in its area of outcrop, varies from typical chalks to calcareous clays, it is probably present in Union County, but because of this lithologic variation it may not be easily distinguished from the overlying Marlbrook marl. The boundary between the Marlbrook marl and the Annona tongue of the Austin is provisionally drawn at the upper surface of a persistent limy or chalky series. As thus identified the Annona tongue in Union County consists of strata recorded in logs as limy shale, gypsum, and gumbo, with some "rocks," sandy shale, or chalk; its thickness ranges from 60 to 100 feet.

---

[2]U. S. Geol. Survey Press Notice: Oil from the Nacatoch sand, El Dorado, Ark., Feb. 7, 1922.

[3]U. S. Geol. Survey Press Notice: Oil from the Nacatoch sand, El Dorado, Ark., Feb. 7, 1922.

Brownstown marl.—The strata referred to the Brownstown marl are dominantly calcareous sandy shales. They are usually called sandy shale, hard shale, "rock," sand, and gumbo in drillers' logs. Subordinate amounts of limestone, "boulders," "pyrite," gypsum, and chalk are frequently noted. The thickness of the Brownstown marl ranges from about 200 to nearly 300 feet and apparently increases westward.

The formation is unique among those penetrated in that its thickness seems to decrease eastward across Union County. This fact doubtless is associated with a marked increase in sandiness of the Brownstown from its outcrop in Hempstead County southeastward through Union County. Any conclusions as to the cause of these changes would be unwarranted if based entirely on evidence furnished by records of rotary-drilled wells, but the presence of these sandy layers may well justify a thorough test of this formation.

Blossom (?) sand.—A group of beds below the Brownstown marl, consisting of about 65 feet of sandstone, shale, and some calcareous layers, is probably to be correlated with the upper part of the Bingen formation of southwestern Arkansas and is therefore tentatively referred to the Blossom sand. The Bingen formation is considered by L. W. Stephenson "as the probable near-shore equivalent of the Blossom sand, the Eagle Ford clay, and part of the Woodbine sand, but these formations are probably represented in part by unconformities within the Bingen and at its base. Indeed, it is possible that the Woodbine sand is entirely represented by the unconformity at the base of the Bingen." Sandy layers in the upper part of the Blossom (?) sand commonly carry water and are thought to correspond to the oil sand or sands in the Haynesville field, in Louisiana, although the formations there have not been positively identified. The Blossom (?) sand lies from 800 to 850 feet below the top of the Nacatoch sand over most of Union County and probably about 810 to 830 feet in the productive part of the El Dorado field.

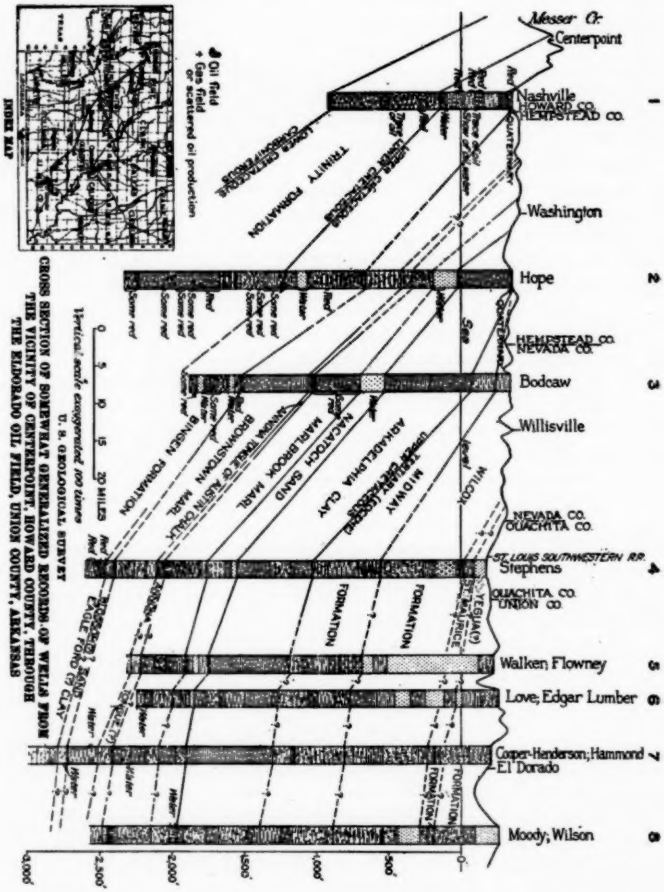
Eagle Ford (?) clay.—The several hundred feet of calcareous or limy shales below the Blossom (?) sand that have been penetrated in Union County probably belong to the Eagle Ford (?) clay of Upper Cretaceous age. In the logs of some wells in and near Union County a few red layers are recorded from these shales (see the accompanying cross section), and in parts of the Bingen formation of southwestern Arkansas that are presumably to be correlated with the true Eagle Ford clay much reddish material has been noted, both at the outcrop[4] and in wells.[5]

The principal oil sands of the Caddo and DeSoto-Red River districts,

[4]Miser, H. D., and Purdue, A. H., Gravel deposits of the Caddo Gap and De Queen quadrangles, Ark: U. S. Geol. Survey Bull, 690, pp. 22-24, 1919.

[5]Miser, H. D., and Purdue, A. H., Asphalt deposits and oil conditions in southwestern Arkansas: U. S. Geol. Survey Bull. 691, pp. 282-291, 1919.

in Louisiana (which are commonly but erroneously called the Woodbine sand), are probably of Eagle Ford age.[6] The horizon of these oil-bearing



CROSS SECTION OF SOMEWHAT GENERALIZED RECORDS OF WELLS FROM THE VICINITY OF CENTERPOINT, HOWARD COUNTY, THROUGH THE ELDORADO OIL FIELD, UNION COUNTY, ARKANSAS

strata in Louisiana is estimated to lie 500 feet more or less, below the top of the Blossom (?) sand in Union County, Ark., and from about 1,300

[6]Matson, G. C., and Hopkins, O. B., The De Soto-Red River oil and gas field, Louisiana: U. S. Geol. Survey Bull. 661, pp. 113-116, 1918.

to 1,400 feet below the upper surface of the Nacatoch. So far as known, this horizon has not been reached in Union County.

***A Deep Well near El Dorado.*—Detailed information regarding the nature of the beds penetrated may be obtained from the following record of one of the deepest wells in Union County:**

Driller's record of Hammond Well No. 1, of Cooper & Henderson Oil Co., is SE¼ SW¼ sec. 19, S. 17 W., R. 15 W.

(Elevation above sea level about 204 feet. Geologic correlations by U. S. Geological Survey. All formational boundaries are fixed tentatively except that between the Arkadelphia and Nacatoch.)

Material	Thickness	Depth
Eocene series:		
Claiborne group:		
Yegua (?) formation:		
Surface sand	30	30
Sand	20	50
Gumbo	11	61
Packed sand	6	67
Hard sand	20	177
Packed sand	40	110
Hard sand	45	155
Rock	2	157
Hard sand	20	17
Gumbo; set 12½-inch casing	4	181
Gumbo	6	187
Sand and boulders	6	193
Packed sand and bouders	20	213
Gumbo	25	238
Rock and sand	2	240
Packed sand	10	250
Sandrock	5	255
Sand and Boulders	3	258
Sand, boulders, and gumbo	100	358
St. Maurice formation (position of contact doubtful; lies above in the 100 feet of sand, boulders, and gumbo):		
Sand and boulders	18	376
Rock	2	378
Packed sand	9	387
Rock	3	390
Gumbo	10	400
Sand and gumbo	20	420
Gumbo	22	442
Wilcox formation:		
Boulders	62	504
Sand & boulders	14	518
Packed sand	18	536
Boulders	36	572
Sand & boulders	130	702
Gumbo	6	708
Sand & boulders	43	751
Gumbo	54	805
Gumbo & boulders	8	813
Rock	4	817
Gumbo	48	865
Rock	3	868
Gumbo & boulders	38	906
Gumbo	5	911
Gumbo & boulders	42	953
Packed sand	10	963
Broken sandrock	6	969
Gumbo	20	989
Sand	16	1,005
Sandrock	19	1,024
Midway formation:		
Hard sand	6	1,030
Gumbo	6	1,036
Gummy shale	20	1,056
Sand & boulders	27	1,083
Gumbo	15	1,098
Sand & sandrock	7	1,105
Broken formation	36	1,141
Sandy gumbo	15	1,156
Gumbo	71	1,227
Shale	12	1,239
Sand & boulders	11	1,250
Gumbo	34	1,284
Rock	3	1,287
Gumbo	14	1,301
Lignite	5	1,306
Gumbo	34	1,340
Rock	1	1,341
Sand	12	1,353
Sand & boulders	8	1,361
Gypsum	31	1,392
Gumbo	119	1,511
Rock	6	1,517
Upper Cretaceous or Gulf series:		
Arkadelphia clay:		
Gumbo	33	1,550
Hard shale	5	1,555
Gumbo	40	1,595
Shale	5	1,600
Gumbo	30	1,630
Gummy shale	64	1,694
Gumbo	52	1,746
Shale & gumbo	65	1,811
Shale & boulders	10	1,821
Shale	23	1,844
Gummy shale	18	1,862
Shale & gumbo	30	1,892
Gumbo	27	1,919
Gypsum	10	1,929
Hard shale	20	1,929
Gumbo	47	1,976
Gumbo & shale	44	2,020
Hard shale & gumbo; set 8¼-inch casing	25	2,045
Gumbo	5	2,050
Gumbo & shale	46	2,096
Shale & gumbo	15	2,111
Nacatoch sand:		
Hard lime & shale	6	2,117
Gumbo	20	2,137

Material	Thickness	Depth
Broken rock	3	2,140
Sand	8	2,148
Broken rock	2	2,150
Sand	10	2,160
Rock	4	2,164
Sand	6	2,170
Shale & boulders	14	2,184
Gumbo	5	2,189
Gummy shale	24	2,213
Shale & gumbo	48	2,261
Gummy shale	26	2,287
Shale & lime	14	2,301
Marlbrook marl:		
Shale & boulders	45	2,346
Gummy shale	41	2,387
Shale & boulders	14	2,401
Hard shale	110	2,511
Salt-water sand	8	2,519
Rock	2	2,521
Sandrock	7	2,528
Sandy shale	2	2,530
Gummy shale	5	2,535
Rock	2	2,537
Gummy shale	7	2,544
Shale	4	2,548
Sandy shale [a]	4	2,552
Hard shale	13	2,565
Rock	2	2,567
Gumbo	57	2,624
Hard shale	5	2,629
Annona tongue of Austin chalk (?):		
Broken sandrock	8	2,637
Hard shale	13	2,650
Gumbo	12	2,662
Hard sand	3	2,665
Rock	4	2,669
Gumbo	6	2,675
Lime & shale	25	2,700
Rock	2	2,702
Browntown marl:		
Lime & shale	25	2,727
Gumbo	7	2,734
Rock	6	2,740
Gumbo	15	2,755
Hard sandy shale	10	2,765
Gumbo	9	2,774
Sand, showing salt-water	6	2,780
Gumbo	12	2,792
Hard gummy shale	22	2,814
Rock	16	2,830
Hard sandy shale	47	2,877
Gumbo	5	2,882
Hard shale	12	2,894
Rock	4	2,898
Shale	3	2,901
Shale & gumbo	5	2,906
Hard sandy chalk	4	2,910
Sandy chalk	14	2,924
Hard shale	15	2,939
Blossom (?) sand:		
Sand	16	2,955
Rock	3	2,958
Sand	2	2,960
Sandrock	2	2,962
Gumbo	20	2,982
Sandy shale	8	2,990
Shale & boulders	1	2,991
Rock	1	2,992
Sand	6	2,998
Sand & gravel	7	3,005
Eagle Ford (?) clay:		
Gumbo	14	3,019
Gummy shale	7	3,026
Gumbo	22	3,048
Gummy shale	9	3,057
Broken limerock	28	3,085
Shale	7	3,092
Broken limerock & shale	22	3,114
Shale	6	3,120
Broken limerock	20	3,140
Shale	6	3,146
Broken limerock & shale	17	3,163
Broken lime & shale	37	3,200

[a] A small fossil obtained from this depth indicates that these beds are no older than the Marlbrook marl. U. S. Geol. Survey Press Notice: Oil from the Nacatoch sand, El Dorado, Ark., Feb. 7, 1922.

Geologic Structure in the Region.—The accompanying cross section, from the vicinity of Centerpoint, Howard County, Ark., in the Caddo Gap quadrangle, to a point about 10 miles east of El Dorado, Union County, shows the general slope and the general increase of thickness of the formations as the center of the embayment is approached is readily apparent.

The elevation of the surface as shown is based on a partial revision of a map previously published by the Survey,[7] and is included in this diagram to show the relation of outcrops to formations below the surface and the depth of the oil and gas bearing sands. Topographic details

[7] Harris, G. D., Oil and gas in Louisiana: U. S. Geol. Survey Bull. 429, pl. 12, 1910.

Elevations of Nacatoch sand and intervals between Nacatoch and and Blossom (?) sand at some wells drilled in south-centeral Arkansas.

Company and lease.	Location					Reported Total depth of well	Depthto top of Nacatoch sand	Elevation of well.	Depth of top of Nacatoch sand below sea level.	Interval between top of Nacatoch sandandtop of Blossom (?) sand.
	Well No.	Sec.	T.S.	R.W	County.					
						Feet.	Feet.	Feet.	Fe7t.	Feet.
Carlton & Owens, McGough lease	1	SW ¼ SW ¼ 16	17	13	Union	2,136	a 2,350	b 262	a 2,088 ?	Feet.
Penn-Wyoming Oil co., Union Sawmill. lease	1	21	18	13	do.	3,089	c 2,386	b 209	c 2,177 ?	....
E. M. Brown Goodwin lease	1	NE. ¼ SW ¼ 16	16	14	do.	2,634	2,160	b 213	1,947	....
Wilson Oil Co., Moody lease	1	NW ¼ SW ¼ 16	17	14	do.	2,815	2,220	b 252	1,968	....
South Arkansas Oil & Gas Co., McCurry lease	1	NW ¼ SW ¼ 19	17	14	do.	2,190	2,165	b 165	1,955	....
E. M. Brown, Grace lease	1	SW. ¼ NE ¼ 3	18	14	do.	2,160	a 2,250	b 253	1,997 ?	....
Quaker City Petroleum Co., Mittendorf lease	1	SW ¼ SE. ¼ 15	17	15	do.	3,010	2,141	b 192	1,949	834
Cooper & Henderson, Hammon lease	1	SE. ¼ SW. ¼ 19	17	15	do.	3,200	2,11	204	1,907	828
Carter & Morgan Syndicate, McKinney lease	1	SE. ¼ NW ¼ 4	18	15	do.	2,881	2,115	b 206	1,909	....
Mountzet al., Tillman lease	1	NW ¼ NE ¼ 9	18	15	do.	2,140	2,140	b 232	1,908	....
Congress Oil Co., Swilley lease	1	SE. ¼ NE. ¼ 8	19	15	do.	2,522	c 2,120 ?	b 227	c 1,893 ?	....
White Oil corp. Murphy LandorEdgar Lumber Co. lease	1	NW ¼ SW ¼ 22	18	16	do.	3,025	2,025	b 159	1,886	830
Milo Drilling Co., Robins or Trimble leas	1	1	19	16	do.	2,586	2,094	b 182	1,912	....
Nebraska Oil Co., Gallagher lease	1	NE. ¼ SE. ¼ 3	17	17	do.	2,110	1,938	b 178	1,760	....
Walker Drilling Co., Flourney lease	1	5	17	17	do.	2,533	1,980	b,d 220	d 1,760	....
Love Petroleum Co., Darden or Edgar Lumber Co., lease	1	SE. ¼ NW ¼ 23	17	17	do.	2,505	2,112	b 256	1,856	....
Forest Oil Co., Mayfield lease	1	NE ¼ NE. ¼ 21	18	17	do.	2,914	c 2,098 ?	e 300	c,e 1,798 ?	812
Hinton & Mattocks, Murphy lease	1	SW ¼ S E. ¼ 29	19	17	do.	2,008	2,110	b 234	1,876	f (?)
Carter Oil Co., at Hadnett, Ark		NE ¼ NE. ¼ 28	14	18	Ouachita	3,240	c 1,790 ?	e 200	c,e 1,590 ?	g856 ?
Trinity Petrolum Co., Realty Color lease	1	NW. ¼ 21	18	18	Union	2,800	1,967	e 275	e 1,692 ?	g809 ?
Louisiana Oil Refining Co., Allen lease	1	NW ¼ SE. ¼ 13	15	19	Ouachita	2,777	1,720	b 170	1,550	842

a Nacatoch sand not reached. Depth to top estimated.

b Well elevations obtained from the oul companies; fairly reliable and, except for isolated wells far from the railroads, are probably correct within 20 feet. Elevations neat El Dorado are based on the bench mark at the El Dorado Court House, the true elevation of which is about 3. feet above that used for it.

c The upper surface of the Nacatoch sand could not be recognized definitely from the drilier's log.

d Two well elevations are given in this section. Uncertainty exists as to which is the proper one.

e Well elevations determined by estimation and from map in U.S. Geol. Survey Bull. 429 (Pl. 12). May be as much as 100 feet in error.

f Blossom (?) sand could not be recogbized from the driller's log.

g The upper surface of neither the Nacatoch nor Blossom (?) sand could be recognized definitely from the driller's log.

near the wells are necessarily obscured because of the exaggerated width of the graphic logs. The records of the Nashville, Hope, and Bodcar wells with correlations[8] and the outcrops of the formations[9] were taken.

The strata recorded in a number of the available logs of wells drilled in and near Union County were also correlated and the results are given in the descriptions of the formations. Maps showing the structure of the Nacatoch and other formations in south-central Arkansas have been prepared by Veatch.[10] A general structural contour map of Union County has not been made, as a sufficient number of well logs for that purpose has not been obtained, but the position relative to sea level of the upper surface of the Nacatoch sand and other interesting features of the wells studied are given in the preceding tabulation.

W. W. Rubey.

EL DORADO OIL FIELD IN ARKANSAS NOT ON AN ANTICLINE

DISCOVERY AND DEVELOPMENT

The El Dorado oil field, in Arkansas, was discovered by the Constantine Refining Co., when their Armstrong No. 1 well, in sec. 1, T. 18 S., R. 16 W., struck an immense flow of gas, estimated at 40,000,000 cubic feet a day, and a small quantity of oil. The oil men of the mid-Continent region paid comparatively little attention to this discovery for several months, although a few companies, acting on the advice of geologists, leased some land near the gas well, but when a well drilled by Mitchell & Busey in sec. 31, T. 17 S., R. 15 W., came in, on January 10, 1921, with a flow of about 1,500 barrels of oil a day, and perhaps ten times that much water, there was a stampede for the field. Leasing and drilling were pushed with an intensity so tremendous that in spite of several months' delay in getting an adequate pipe-line outlet for the oil produced the field was developed with remarkable rapidity. The oil sand is only about 2,150 feet below the surface, and the rocks above it are mostly beds of shale and clay that are easily penetrated by the rotary drill. Wells that gave a large output were the rule rather than the exception, several yielding more than 10,000 barrels a day, although most of these wells produced much salt water with the oil. The output reached about 82,000 barrels a day during the week ending August 20, 1921, but declined rapidly to about 32,000 barrels a day during the

---

[8]Miser, H. D., and Purdue, A. H., Asphalt deposits and oil conditions in southwestern Arkansas: U. S. Geol. Survey Bull. 691, pp. 282-292, pl. 33, 1919.

[9]Harris, G. D., Oil and gas in Louisiana: U. S. Geol. Survey Bull. 429, pl. 12, 1910.

[10]Veatch, A. C., Geology and underground water resources of northern Louisiana and southern Arkansas: U. S. Geol. Survey Prof. Paper 46, 1906.

week ending March 11, 1922. Since then the output has increased slightly.

STUDIES OF THE GEOLOGY OF THE FIELD

Field studies of the geologic structure were made in the summer of 1921 by W. W. Rubey, L. G. Mosburg, and H. W. Hoots, of the United States Geological Survey, and office studies were afterward made by K. C. Heald and W. W. Rubey. The primary purpose of these studies was to learn the conditions under which oil is most likely to occur in southern Arkansas. The investigation was afterward extended to ascertain the relations of the oil to the water in the strata for the information of the engineers of the Bureau of Mines, who were working in cooperation with the State.

Each oil-yielding district has its own peculiarities, and the rules that may guide prospecting in one area may not apply to another. The great number of test wells that have been drilled in southern Arkansas without finding oil in large quantity except in the El Dorado field show either that the oil pools in this region do not bear the same relations to anticlinal structure that they commonly bear elsewhere in the mid-Continent oil fields or that geologists have not learned how to locate the anticlines in this field by studying the surface formations. If the geologist is without definite rules to guide him in discovering oil pools, his usefulness is much less than it otherwise would be, and the operator must hunt for new pools blindly, so that his chances of success will be reduced and the average outlay for each pool he may find will be greatly increased. Random drilling has discovered many great oil fields, and persistent prospecting without geologic guidance would ultimately find every pool, just as a blindfolded man could find almost any object he sought if he sought long enough, but this is no reason why the blindfold should not be removed if it can be removed. One of the most effective aids in locating undiscovered pools is an accurate, thorough knowledge of the conditions in fields that have been developed, and any one who hopes to find new pools in southern Arkansas should study the El Dorado field and the fields to the south in Louisiana.

STRUCTURE OF THE FIELD

The geologic structure of the El Dorado field is unlike that of any other known field of similar size. The studies made covered only the northern part of the producing area, but there is no reason to think that the structure of the southern part is materially different. If the sand, clay, and gumbo could be stripped off the producing bed in the area covered by the map no large dome or great anticlinal arch would be seen. The surface of the oil sand is so nearly level that it might remind one of gently rolling prairies or of meadows made up in part of smoothly rounded knolls and swales or hollows whose slopes rise in even, sweeping curves. The evenness is interrupted by a number of low, almost vertical cliffs that mark faults where the rock has been broken and one side of

the break has risen from 1 to 30 feet above the other. There are probably a great many more of these breaks than are shown on the map. Almost without exception they trend northeastward, forming a sharp angle with the longer axis of the field, and most of the low folds that vary the flatness of the surface of the oil sands also trend northeastward.

The oil sand rises righer in sec. 1, T. 18 S., R. 16 W., than elsewhere in the part of the field that has been mapped. Not enough wells have been drilled in this part of the field to enable the geologist to work out its structure in detail, but it seems more nearly anticlinal than the narrow oil-yielding area that borders it on the northeast, east, and southeast. The few well records available indicate that in this part of the field there is a real dome on which the beds dip gently to the east and more abruptly to west and southwest. The wells on the dome yield gas and a little oil. Between this dome and the oil-yielding belt to the east there is a rather broad area over which the structure has not been worked out, so that the impression of flatness in that area given by the map is unjustified.

The structure in the area west and south of the gas-yielding dome, in sec. 1, is not known, but the few records that are available show that the oil sand there is fully as high as it is in the productive part of the oil field.

A study of well records in areas east and west of the El Dorado field shows that this field is not upon a pronounced regional uplift, although there may be a slight bulge or gentle arch in the El Dorado region. The strata dip gently to the east and southeast over most of southern Arkansas. If the El Dorado field is on a regional bulge or uplift there is a synclinal depression west or northwest of it. A flattening of the regional dip was detected but no true syncline. Furthermore, if the field were on an uplift the strata immediately east of it would probably show steeper dips than are common in this region, but no suggestion of such steep dips was found. The location of this field is therefore not controlled by the manner in which the rocks are folded. There is no true major anticline here, and the minor folds did not control the distribution of the oil, although the gas in this pool does tend to concentrate in arched or domed areas. The part of the field in which, as shown by the map, the structure is anticlinal lies in a sinuous belt that trends in general at little west of north through the center of sec. 31, T. 17 S., R. 15 W., including about 40 acres in the NW¼ sec. 5, T. 18 S., R. 15 W., about 60 acres in the northeast corner of the same section, about 60 acres in the north-central part of sec. 8, T. 18 S., R. 15 W., and about 100 acres in the southwest corner of sec. 7, T. 18 S., R. 15 W. besides the gas-yielding dome in sec. 1, T. 18 S., R. 16 W. In no one of these areas are there oil wells that show productivity above the average or the freedom from water trouble that might be expected if the segregation of oil were controlled by anticlinal structure. If the dates of completion and of average decline in initial production are taken into con-

sideration in order to compensate for interference from adjacent producers, the wells in these anticlinal areas are perhaps a little above the average for the entire field, but this initial production is not higher than that of wells in adjoining synclinal areas.

On the other hand it can not be said that in this field there is no relation between geologic structure and the accumulation of oil, for structure includes both folds and faults, and the faults were probably influential in forming the pool. Nearly every area of high productivity in the oil-yielding belt here considered is traversed by one or more faults. A strip of richly productive territory does not border each fault shown on the map, but here and there along almost every fault there is a spot of unusual richness.

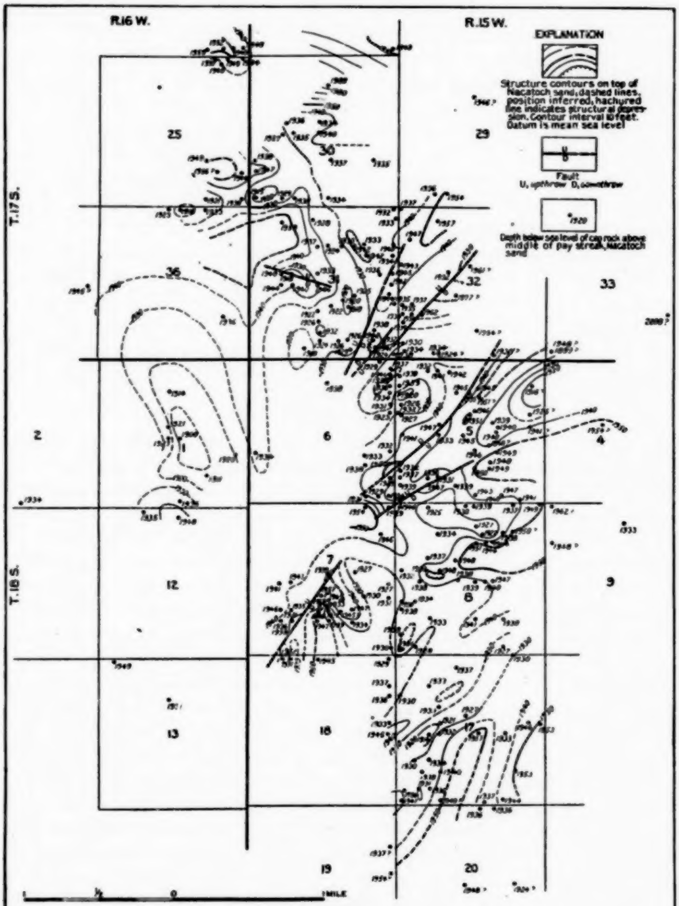
The direction and arrangement of the faults, and the shapes of the low folds that accompany some of them, probably indicate the presence of a large fault or zone of faulting in the beds deep below the Nacatoch sand, trending about N. 15° W. The structure shown by the oil sand there must have been produced by lateral movement along this fault, the strata east of it moving northward relative to the strata west of it.

HOW THE POOL WAS FORMED

The Marlbrook marl is believed to be the source of the oil in this field, and the accumulation of enough oil in the Nacatoch above the Marlbrook to form a commercial field is probably due to a happy association of a source of oil channels through which it could migrate, and a good reservoir bed. Oil was probably not formed everywhere in the Marlbrook, at least not in great volume, but in favored spots where it was laid down in shallow water and possibly raised above the sea from time to time, the conditions were right for the deposition and preservation of oil-forming matter. In any event, in some places the Marlbrook appears to have supplied large amounts of oil to the overlying Nacatoch sand, and in others, where the structure is seemingly quite as favorable, it has supplied little or none. At El Dorado the zone of faults crossed a productive area in the marl. The oil moved up along the fault planes and accumulated in the upper part of the Nacatoch sand. Pronounced anticlinal folding and faulting and a rich spot in the Marlbrook would together have produced ideal conditions for the accumulation of oil, and under such conditions the water trouble that has been the curse of the El Dorado field would not have appeared. The beds of sandstone lie so flat, however, that the oil they contain does not saturate them to any great thickness; but instead it is found in thin layers at the tops of several beds in the upper part of the Nacatoch, and the remaining parts of these beds are filled with salt water. The gas being more mobile than the oil has migrated to the more prominent domes and has excluded most of the oil and the water from certain thin beds of sandstone under the arched areas.

If the formations just above the Nacatoch had contained porous sand-

stones, the oil, as it moved upward along the fault planes, would probably have formed small pools in them, for the faults are not limited to



U. S. GEOLOGICAL SURVEY
GEOLOGIC STRUCTURE OF NORTHERN PART OF EL DORADO OIL FIELD, ARKANSAS
BY E. C. HEALD AND W. W. RUBEY

the beds below the top of the Nacatoch but certainly cut the Arkadelphia clays, although these beds contain few sands. The faults may cut also the Midway beds, although this supposition can not be definitely

verified by the well records, but no evidence was found to indicate that they cut the Wilcox.

Instead of originating in the Marlbrook the oil possibly may come from a much deeper formation, such as the Brownstown marl, the Eagle Ford shale, or the Lower Cretaceous beds. The depth of these formations below the Nacatoch is no obstacle to the migration of oil, for the faulting that cuts the Marlbrook must also cut them, and if it could furnish channels for upward migration from the Marlbrook to the Nacatoch it could almost as easily furnish channels for migration from the deeper beds. If the oil came from the Brownstown marl there may be chances of finding oil-reservoir beds in this formation or adjacent to it, and if it came from the Eagle Ford shale there is a good chance of obtaining it from the Blossom and Woodbine sands.

If the oil came from the Marlbrook marl, however, the chances of obtaining it from underlying formations are not exceptionally good, although these lower formations should not be utterly condemned. The records of other fields that draw oil from Upper Cretaceous formations prohibit such a blanket condemnation, for practically all fields that have yielded either oil or gas in notable amounts from the Nacatoch sand have yielded much greater amounts from either the Blossom or the Woodbine sands or both. The lack of anticlinal structure at El Dorado, however, offsets this favorable feature. Where oil has been found in the Blossom or the Woodbine there is either pronounced regional uplift or strong anticlinal folding. In the Caddo and De Soto-Red River districts there are both. In the El Dorado district there is neither. The conditions that are associated with oil pools in northern Louisiana, and to which the formation of those pools is presumably due, are therefore lacking here, and production from the deep beds can not be counted on. Nevertheless, the deep sands should be tested. The most promising locality for a deep test well, so far as the map shows, is the west side of the gas-yielding dome in sec. 1, T. 18 S., R. 16 W. The very center of the section seems to be a good location for such a test well, but as it is desirable to hake a test for oil in the Nacatoch at a place west of the gas-bearing area, a location 800 feet west of the center of the section would probably be preferable.

OIL AND GAS ABOVE THE PRINCIPAL "PAY" SAND

A few wells in the El Dorado field have reported "showings" of oil or gas in beds in the Midway formation. A few reports that traces of oil have been found in these beds might be discredited, for enough oil to give a rainbow-colored film on the drilling water might accidentally get into a well, but showings of gas could not be thus explained, and it therefore seems evident that at least one bed in the Midway formation carries some oil and gas. This bed may lie about 1,150 feet below the surface over most of the field, or about 970 feet above the Nacatoch sand. A number of sands in a zone 200-300 feet thick may carry this

shallow oil. The wells in which it is reported do not lie on anly of the faults that have been mapped or very near them, a fact which indicates that the oil probably did not rise along those faults.

Reported showings of oil or gas in a number of wells that have been drilled within a radius of 40 miles of the El Dorado field suggest that an oil-bearing sand may lie at the base of the Midway formation, tacular but less reliable wells that get oil from the underlying Nacatoch No careful tests of these shallow beds seem to have been made in the field in spite of the very apparent need for such tests. Small water-free wells that would draw oil from a bed not more than 1,200 feet below the surface would probably yield greater net profits than the more spectacular but less reliable wells that yet oil from the underlying Nacatoch sand. Tests of the shallow sands should be made very carefully, for the gas in them is evidently under low pressure, and it would be easy for one to drill through a thin oil or gas bearing sand without suspecting its presence.

POSSIBLE EXTENSIONS OF THE FIELD

In the part of the field covered by this study the location of highly productive wells near faults suggests the desirability of drilling in the southwest corner of sec. 7, T. 18 S., R. 15 W., and in the adjoining territory in secs. 12 and 13, T. 18 S., R. 16 W. The field may probably also be extended in the SE¼ SE¼ sec 32, T. 17 S., R. 15 W., and there seems to be no indication that the producing territory will not also include parts at least of the SW¼ sec. 33, T. 17 S., R. 15 W., and of the NW¼ NW¼ sec. 4, T. 18 S., R. 15 W. A well in the NW¼ sec. 7, T. 18 S., R. 15 W., should yield either oil or gas, particularly in the eastern part of center of the N½ sec. 2, T. 18 S., R. 16 W., and the center of the N½ sec. 12, T. 18 S., R. 16 W.

A number of test wells should be drilled west of the gas-bearing area, for oil-bearing beds may possibly border the gas-bearing beds on the west and south as they do on the north and east. Suggested locations for test wells are the northeast corner of sec. 2, T. 18 S., R. 16 W., the center of the N.½ sec. 2, T. 18 S., R. 16 W., and the center of the N.½ sec. 12, T. 18 S., R. 16 W.

The extension of the field to the south of its present limits is to be expected, and determined prospecting to discover a northward extension is also justified by the peculiar type of structure. Operators should not accept a single dry hole as limiting the field in these directions. The producing territory at the present north margin of the field can probably be extended westward.

POSSIBILITY OF SIMILAR FIELDS ELSEWHERE IN SOUTHERN ARKANSAS

Parallel belts or faults separated by areas almost unfaulted may occur in southern Arkansas as they do elsewhere in the mid-Continent region, notably in northern Oklahoma and southern Kansas. If such a belt exists within a few miles of El Dorado the other favorable conditions

that combined to produce the El Dorado pool probably also exist there and a field much like the El Dorado field may be developed. Because of this probability the following suggestions are made:

1. If gas in volume is encountered in a wildcat well the search for oil should be continued by wells drilled east, northeast, or southwest of the gasser.
2. If oil is encountered in a wildcat well the extension of the oil-yielding areas should be sought by other wells drilled either north or south of the discovery well.
3. Gas pressure should be conserved by shutting in gas wells. The maintenance of high pressure will help to promote a greater extraction of oil and to prevent water trouble.

The chances for finding new fields are not limited to zones of faulting, for there are probably anticlines in southern Arkansas fully as strongly developed as those on which the Homer and Bellevue fields of Louisiana are located. Even if some of the conclusions here presented may be questioned other oil fields will no doubt sooner or later be discovered in southern Arkansas, for in view of the showings of oil obtained in widely scattered wells in this broad region it would be unreasonable to believe that there is only one place in it where the conditions are favorable to the formation of an oil pool.

DESCRIPTION OF THE PRODUCING BED

The Nacatoch sand in the El Dorado field is about 180 to 190 feet thick. The upper part is principally sand, but the formation also includes shaly sandstone and streaks of gumbo and shale. The lower part varies from slightly calcareous shale to hard limestone, although it generally contains some thin sandy layers.

The top of the sand is commonly marked by hard streaks called "rock" by the drillers. At some places these hard streaks are absent, and drillers who depend on them to indicate the top of the pay sand drilled deep into the sand before they realized that they had reached the oil-bearing bed. In fact the drillers of the Busey well, commonly considered the discovery well of the field, drilled through the bed that yields most of the oil produced from the surrounding wells without recognizing it and obtained oil from a lower pay streak in the sand.

There are at least three pay streaks in the upper part of the Nacatoch. No one of these streaks appears to extend through the field, but the middle one, which is about 40 feet below the top of the sand, is nearly continuous and yields most of the oil. Producing beds both higher and lower than the middle one have made good wells, but these other producing beds appear to be very patchy, or perhaps they have not been adequately tested, for comparatively few wells draw oil from them. The gas well drilled by the Constantine Refining Co., which was the real discovery well of the field, obtained its gas from a bed that lies about 40 feet below the bed which is yielding oil in wells to the east.

In all the pay streaks oil seems to be present only in the topmost few feet of the sand and is everywhere underlain by salt water. Salt water is also closely associated with the gas in the gas-yielding part of the field. Unless a well is completed with the utmost care this water flows from it with the oil and gas from the day it is completed until water flooding causes its abandonment. This water is much more difficult to combat than the water in most pools because there is no such thing in this field as "edge water," which is restricted to the margins of the producing area. So far as salt water in concerned this field may be said to be all "edge," and each well is a problem in itself.

There is no evidence that the Nacatoch is either thinner or more shaly near the edges of the field than elsewhere. It is undoubtedly much more shaly in some places than in others, but no relation between the yield of oil and the percentage of clean sand could be determined.

METHODS USED IN CONSTRUCTING THE MAP

The records of wells drilled with rotary tools are notoriously poor and afford very unreliable correlations. In the El Dorado field comparisons and correlations are particularly hard to make, because the top of the Nacatoch sand varies so little in elevation throughout the field and because no single bed can be easily and certainly recognized everywhere. The results presented on the map are admittedly open to challenge, but they represent very careful and painstaking work,—the best that can be done with the data available.

The correlation of the beds struck in different wells was first attempted soley by noting the relative positions of the beds of sandstone, limestone, chalk, and gypsum recorded by the drillers. The results of these correlations were not satisfactory. Next, the "rocks" recorded by the drillers were colored distinctively on the plotted well logs and were found to furnish a good tie between many of the wells. However, to make satisfactory correlations it was found necessary to assign characteristic symbols or colors to every term employed by the drillers. The record of the hardness was helpful. "Boulders" were in places distinctive. Some of the "pack sands" could be correlated between two or more wells. Shale and gumbo were distinguished, and although the usage of the drillers was not uniform their use of these terms furnished a valuable clue for many areas.

The work thus done permitted the recognition of small faults shown on the map. These faults would have been indicated by the evidence afforded by the oil sands, but this indication had to be confirmed in the upper part of the section. In a record of a well drilled across a normal fault a part of the stratigraphic section is missing, and conversely in a record of one drilled across a reverse fault a part of the section is repeated. In the parts of the map that are based on comparatively few well records the structure appears to be much smoother and simpler

than it is elsewhere, but if more records had been available these apparently simple areas would no doubt prove to be much more complex.

CHARACTER OF THE OIL

Detailed analyses of the oil from the El Dorado field, published by the United States Bureau of Mines in November, 1921, show that its gravity is about 34.2 Baumé and that it contains about 30 per cent of gasoline and naphtha and 13 per cent of kerosene, the remainder being gas oil and lubricating oil.

K. C. HEALD AND W. W. RUBEY

THE FOX OIL AND GAS FIELD, CARTER COUNTY, OKLA.

The Fox oil and gas field, located in T. 2 S., R. 3 W., Carter County, Oklahoma, includes sections 19, 20, 21, 22, 26, 27, 28, 29, 32, 33, 34, and 35. The area described is in the northwest corner of Carter County about 33 miles by road from Ardmore, the county seat.

The first producing well in the district, the No 1, W. B. Johnson, was completed as a gas well in the summer of 1916 by the Gypsy Oil Company. It is located in the southwest quarter of sec. 28, T. 2 S., R. 3 W. Its initial volume was 25 million cubic feet per day. The old Fox gas field was somewhat slow to develop and to date does not show the complete development of the proven territory. The discovery of oil producing sands within the gas area increased activities and in February, 1919, the Empire Gas and Fuel Company extended the field to the east by completing their No. 1 Davis, in the center of the SW¼ NE¼ of sec. 34, as an oil well having an initial production of 150 barrels per day. In July, 1920, the Humble Oil and Refining Company increased activities further in the eastern part of the field by completing their No. 2 Davis, in the NE¼ NE¼ of sec. 34, as an oil well with an initial production of 50 barrels daily. At this time, the price of crude oil was high and intensive development began in sec. 34 and 27. To date, the eastern part of the field has been better developed than the old gas field, due principally to the greater accumulation found.

The district is within the "Red Beds" plains province not far west of the Arbuckle plateau. Prominent escarpments mark the topography and are covered by thick growths of scrub or "jack" oak. The area is drained by Caddo Creek to the north of the field. The drainage is principally to the southeast. A very small percentage of the land is in cultivation. The roads are only fair.

The Fox anticline, like that of the Velma district farther to the northwest, has been known for some time and is a prominent and distinct structural feature. The major axis extends in an approximate northwest-southeast direction. The dips to the northwest are comparatively steeper than those to the southeast. The anticline has an approximate closure of 60 feet.

The rocks exposed are of Permian age probably the same group of sandstones and shales found in the Velma region to the northwest. Considerable slumpage has taken place and most of the exposures are greatly broken.

It is surprising to note the number of horizons producing in the district. The range of production over the entire area is from 150 to 2450 feet below the surface. The horizons are tabulated below, the range of each being only approximate and depending somewhat on structural conditions, dips, etc.

Depth of Sand	PRODUCTION	*Where Producing*
150-200 feet	Heavy Oil	31-2S-2W
230-300 "	" "	31-2S-2W
400-500 "	Gas	6-3S-2W
625-700 "	"	31-2S-2W, 6-3S-2W
875-900 "	"	31-2S-2W, 6-3S-2W, 26, 27, 35, 36, 2S-3W.
1450-1500 "	"	31-2S-2W
1530-1600 "	"	29-2S-3W, 31-2S-2W
1650-1750 "	Light Oil and Gas	29-2S-3W, 18-2S-2W
1790-1850 "	Gas	28-2S-3W
1880-1950 "	"	28, 29, 35, 2S-3W
1980-2050 "	"	28, 29, 2S-3W

Between 2050 and 2400 feet, some four sands are producing which are confusing when tabulated. These sands comprise the best producing zone, the chief sand being found between 2225 and 2380 feet. The initial productions from this sand range from 100 to 500 barrels per day. It is best developed in secs. 27, 34 and 33 of T. 2 S., R. 3 W.

A well in sec. 18, T. 2 S., R. 2 W., is producing from a sand at 2432 to 2488 feet below the surface. The well had an initial production of 60 barrels settling to 6 barrels per day.

The producing sands below 1500 feet are thought to be of Pennsylvanian age, probably belonging to the Glenn formation of Lower Pennsylvanian age.

The initial productions of oil wells in the district range from 6 to 500 barrels per day. The initial gas volumes, from 3 to 60 millions cubic feet per day. From a production report of March, 1922, the average daily production of the field was 3230 barrels from 58 oil wells. A greater part of this is from secs. 27 and 34.

Most of the oil has a gravity of between 34 and 36 Baume. The higher gravity comes from the deeper sands. The shallow wells produce oil varying from 24 to 28 degrees Baume. The Sinclair Pipe Line Co., handles most of the production.

The old Fox field is principally gas from some 33 wells. The Consumers Light and Power Co. of Ardmore contracts for the greater part of this and in turn supplies the city of Ardmore.

There have been 152 wells drilled, including both shallow and deep, of which 22 were dry. The dry hole percentage is approximately 14.

The cable tool method of drilling was used entirely in developing the gas field and not until the summer of 1920 was the rotary method introduced. The heavy gas pressure found in the upper sands make the cable tool method impracticable in the rapid development of the lower pay sands. The average cost of a rotary hole to a depth of 2200 feet is about $16,000. The use of nitroglycerine in shooting the sands is not a practice as yet in the field as the horizons are sufficiently soft and open to give up the oil readily.

Renewed activity in the coming summer will further outline the field and important new developments are looked forward to with interest.

WILLIS STORM

OIL "SHOWING" IN GRANITE IN SOUTH AFRICA EXPLAINED[1]

Showings of oil from a deep well drilled at N. W. Cape Province, South Africa, were investigated in 1921 by Dr. Wagner, Government geologist, whose findings should be of interest to all oil geologists.

The hole was bored with a diamond drill to a depth of about 4,610 feet. The upper 2,700 feet was through sediments mainly of the Dwyka series, from which a little gas was obtained. At about 2,700 feet the drill went into granite, and at 4,610 was in garnetiferous gneiss-granite. It was from this gneiss-granite that most of the "oil shows" came. These shows consisted of oil films on the drilling water and oily material in the slush from the well.

Doctor Wagner proceeded with painstaking care to prove the source of these oil showings. He was naturally convinced that they did not originate in the granitic rocks. A similar statement to that effect, however, would not have been convincing to the average oil operator. The geologists' belief that oil will not originate in granite is not nearly as convincing as the equally emphatic statement of a driller to the effect that he had actually obtained such oil when drilling in rocks classed by geologists as granite. There could be no question as to the actual existence of the oil shows. The source of the oil therefore had to be found.

Investigation showed that the three bottom joints of the drill stem were regularly greased with a mixture of tallow and anti-friction grease. There, then, was a possible source of the oil showings, and many geologists would have been satisfied to point this out and to make a definite, although unproven assertion, that this was undoubtedly the source of the oil. Dr. Wagner's thoroughness merits emulation. He learned how much grease was regularly used, and by figuring the speed of drilling found that it amounted to about 1½ pounds per foot per hole. He made

[1]Published by permission of the Director, U. S. Geol. Survey.

observations on the temperature of the water that came from the hole, caught samples of the oily sludge from the well, and also took samples of the tallow and grease that were userd for lubricating the rods.

Analysis of the anti-friction grease showed that, although it was principally mineral oil, it contained saponifiable matter with saponification value of 29.6. The tallow had saponification value of 201.5. The sample of sludge was extracted with the other, and the grease thus obtained was found to have saponification value of 141.5, showing that it was not mineral oil, and that beyond reasonable doubt it was derived from the mixture used for the lubricating.

A further proof of the origin of the greasy film on the water in the sludge pit was obtained by treating the mixture of the grease and the tallow with water about as hot as that coming from the hole. This test gave greasy films in all respects similar to those on the drilling water.

An interesting feature connected with the drilling of this well was the belief of the drillers, fostered by the occurrence of alternating hard and soft material, that they had encountered an oil sand. This alternation of hard and soft rock was due to the presence of steeply dipping gouge-filled fissures. One such fissure encountered at 4,520 feet was not passed out of until a depth of 4,596 feet had been reached, and the driller's belief that he had found sediments below the granite appears very excusable.

K. C. Heald.

PROPERTIES OF TYPICAL CRUDE OILS FROM THE PRODUCING FIELDS OF KANSAS

The gravities fall between exceptionally narrow limits, 24 of the 27 samples having figures between 27° and 37°B. One, however, 19.4°, one 43.5°, and the third exception, barely over 37°. The average for all samples is 31.8°.

Sulphur contents vary between 0.12 and 0.66 per cent, although the majority of the samples range between the limits 0.20 and 0.40 per cent. The viscosity and pour tests also show only a moderate variation in this respect.

The results of greatest practical significance are those for gasoline and naphtha content, and for carbon residues of the distillation residuums. In the majority of samples the gasoline-naphtha content ranged between 10 and 30 per cent, averaging 22.3 per cent. These figures are in general, more favorable than are usually attributed to Kansas crudes. This seeming discrepancy arises from the fact that in the survey, gasoline and naphtha are grouped together, taking into account only the end point of the cut. The results, therefore, do not indicate whether the material is suitable for motor fuel or requires blending with natural-gas gasoline. However, it was shown that most of the Kansas crudes have relatively high initial boiling points and relatively small percentages of constituents distilling below 100°C (212°F). The

relatively high gravities of the gasoline-naphtha fractions also indicate that blending is necessary if the material is to be used as motor fuel.

In some of the Kansas fields, the oil wells are practically devoid of natural gas, and it was noted that the oils from these fields have, as a rule, unusually high boiling points.

With regard to cylinder stocks and similar lubricating oils, the results of the survey indicate that the average Kansas crude is not favorable material for this purpose. This opinion is based on the fact that the carbon residue from the distillation is for most of the samples more than 8 per cent, whereas experience shows that the best crude oils for this purpose have carbon residues not in excess of 3 per cent and in general should not exceed 6 per cent.

With regard to classification on the basis of the proportionate content of different groups of hydrocarbons, the gravity and viscosity results indicate that the Kansas crudes are intermediate between those of "paraffin base" type, represented by Pennsylvania and West Virginia crudes, and those of the "naphthene base" type, as Gulf Coast and California petroleum. The Kansas crudes are remarkably uniform in their moderate range of variation in viscosity and gravity, especially when contrasted with oils from the Rocky Mountain district, and evidently maintain the same proportional balance between naphthene and paraffin hydrocarbons throughout the entire distillation range.

Copies of the complete serial on the Kansas crudes with tables of distillation results may be obtained on request from the Director of the Bureau of Mines, Washington, D. C.

E. W. Dean, M. B. Cook and A. D. Bauer.

THE HAYNESVILLE, LOUISIANA, FIELD

Since the recent westward extension of the Haynesville (Louisiana) field by the W. H. C. Oil Company's Shaw No. 1, an 1,800 barrel well in sec. 18, T. 23 N., R. 8 W., and the Levert Oil & Gas Company's Hunt No. 1, a 300 barrel well in sec. 7, T. 23 N., 8 W., there have been several interesting developments. It appears that some of these western wells have been drilling too far into the sand and considerable quantities of basic sediment, and salt water have developed. The increase in gas westward may account for some of this basic sediment. The Standard Oil Company's Shaw No. 1., in sec. 19, T. 23 N., R. 8 W., came in at the rate of 7,000 barrels a day, but in a few days was making 70 percent basic sediment although still making 2,500 barrels of fluid. In this well the top of the producing sand was 2,507 feet below sea level. In several other recently drilled adjoining wells, considerable quantities of basic seediments and salt water have developed and it has been necessary to plug back.

The suggestion is again made that since 2,500 feet below sea level seems generally to mark the salt water line in the main part of the field, that great care be taken in drilling in wells in which the top of the

sand lies lower than 2,490 feet below the sea, lest salt water and basic sediment be encountered.

The thickness of the sand actually producing the oil has been greatly overestimated in many cases and has led to deep drilling into the sand. The average thickness of pay sand is not more than 8 or 10 feet, although a number of wells in the eastern part of the field have had up to 15 or 16 feet of pay sand.

The policy of penetrating from 30 to 50 feet of sand in the older part of the field has not been advantageous since in many cases it has brought in salt water, and later increased the basic sediment content of the oil. and has also exposed a greater column of sand, mostly very fine, which has heaved in and abruptly cut off large producing wells, thus accounting to some extent for the sudden decrease in the field's production. In addition the deeper drilled wells will first feel the detrimental effects of the advance of the salt water as the oil is drained off.

Development to date has definitely limited the field on the south, southeast, southwest, and northeast. From the curve of the structure contours the limit of the western part of the field may be defined in the eastern part of sec. 13, T. 23 N., R. 9 W., Webster Parish, Louisiana. On the east the sand is gradually sloping toward the salt water line but is still about 35 feet above it stratigraphically.

The slope of the sand northward is gentle but suggests a rapidly approaching limit.

Within the past few days some oil has been found in the Red Rock Oil Company's well in sec. 10, T. 23 N., R. 9 W., 3¼ miles northwest of the west edge of the Haynesville field. The sand was struck at 2492 feet below sea and commercial oil is probable. Whether the Red Rock well will tie up with the Haynesville field is a matter of doubt, but that it will connect with the Sinclair Oil Company's Mayfield well in sec. 20, T. 23 N., R. 9 W., 3 miles southwest, is probable.

L. P. TEAS.

May 4th, 1922, Shreveport, La.

A METHOD OF DISTINGUISHING FUSED CORES[1]

Several letters have appeared in the Bulletin recently, describing specimens of sediments which had been fused by the friction of the core barrel used in taking cores. A number of such fused cores have been submitted to the U. S. Geological Survey during the past year with the request that they be examined to ascertain if they were igneous rocks. Thus it is evident that fused specimens are frequently mistaken for igneous rocks. Fusion by the friction of the core barrel is a frequent occurrence, and with the increasing use of the rotary drill the

[1] Published by permission of the Director of the U. S. Geological Survey.

question of the presence of igneous material in the rocks penetrated is likely to recur again and again.

Pure sands are very infusible, but shales and especially arkoses and tuffs are relatively fusible, and the partly fused core from such a rock superficially resembles a basalt. Microscopically the habit, composition, and mineral relationships are strikingly different from those seen in a basalt or in fact any igneous rock. A thin section of such material under a microscope shows a ground-mass of brown glass enclosing grains of quartz and feldspar and many small black opaque particles.

Ferromagnesian minerals form a conspicuous part of basaltic rocks, but they are practically absent in fused sediments. Their small resistance to weathering often results in their partial elimination from sediments, and where they are present their great fusibility results in their complete solution in the glass. The feldspars give a superficial resemblance to an igneous rock, but the grains almost never have crystal outlines. Calcic and alkalic feldspars are frequently found in association, as they would not be in an igneous rock. Basaltic rocks seldom contain any quartz, but in the fused cores quartz is abundant and is angular in outline, as it would not be in an igneous rock. The small black opaque grains are fragments of iron and steel derived from the drilling tools. Iron is an extremely rare element in terrestrial rocks and is unknown in association with quartz. The occurrence of iron in the fused cores is the most fundamental and conspicuous difference between them and igneous rocks. If the presence of iron can be established, it constitutes practically conclusive evidence that the material containing it is not igneous in origin. As all fused cores examined contained metallic iron, its presence can be used as criteria as to the origin of the rock.

It is not always convenient to await determinaton till the specimen can be examined by a petrologist, and a method that could be applied in the field by geologists or drillers alike would no doubt interest many oil men. This letter is written to point out that such a simple field test requiring practically no apparatus is available. The method is as follows: Pound some of the material from the core to a fine powder taking care that no steel fragments become mixed with it. Spread on a piece of paper and separate any magnetic material with a small horseshoe magnet. If a magnet is not available, the crushed rock can be panned and the heavy materials concentrated. Transfer the concentrate to a small glass or porcelain dish, add a little water and a few small crystals of copper sulphate (blue vitriol). If iron is present, it will within a few minutes become coated with copper and assume the characteristic metallic copper color. A specimen of the uncrushed rock can be dipped in the copper sulphate solution and the disseminated grains will become copper coated, but they are usually small and inconspicuous and a good hand lens will be required for their identification. The copper coating will become dull, if left in the solution too long, but will again become bright on being rubbed briskly. This formation of a copper

coat gives an almost certain test for metallic iron, and, if iron is present, it affords practically conclusive evidence that the rock is not igneous. If the test is negative, it is not quite so conclusive that the rock is igneous, and it may be necessary to have it examined microscopically before finally concluding as to it origin.

CLARENCE S. ROSS.

OIL IN MIDDLE ORDOVICIAN IN INDIANA[1]

The search for oil in the sub-Trenton formations in Indiana is discussed by W. N, Logan, State Geologist of Indiana, in the Oil News for March 20, 1922, pages 60-61. Details are given regarding a number of wells that have been sunk to the sub-Trenton formations in the state and showings of oil that have been encountered in the St. Peter sandstone of Middle Ordovician age are recorded. The three most significant tests are probably those cited below: :

> "A well drilled recently in Marion County encountered a 30-foot stratum of sand in the upper St. Peter which contained a heavy asphaltic oil. At this point the surface of the Trenton is about 300 feet below the sea level.
>
> In Decatur County a deep well has already passed through the St. Peter into the lower Magnesian. Some gas was found in the upper part of the St. Peter and a porous dolomitic limestone was encountered in the lower Magnesian.
>
> A sub-Trenton test in Clark County, in the southern part of Indiana, encountered a fine white sand in the upper St. Peter which showed slight indications of oil according to samples submitted to the writer."

No other showings have been reported, but if the identification of the formations is unquestionable, these three wells show that the Middle Ordovician of Indiana must be regarded as a possible source of oil and gas. This is all the more true because, so far as Professor Logan is aware, these tests were drilled "without knowledge of their position in relation to the minor structural conditions."

This article by Logan is a warning to oil geologists that it is neither safe nor good geology to place the lower limit of possible oil production in the Trenton or equivalent horizons of Ordovician age. This holds true not only in the Indiana-Ohio district but also in Illinois, Missouri, and the northern Mid-Continent field.

K. C. HEALD.

IS THE STAPLETON PAY OF THE EL DORADO FIELD, BUTLER COUNTY, KANSAS, ORDOVICIAN OR MISSISSIPPIAN IN AGE?

The deep, or Stapleton, pay zone of the El Dorado field of Kansas is reported by Aurin, Clark, and Trager[1] to be composed principally of limestones of Ordovician age with locally a higher sand-

[1]Published with permission of the Director of the United States Geological Survey.

stone which they tentatively correlated with the Tyner formation, also of Ordovician age. This sandstone is described by them as a thin veneer separating the Ordovician limestones from the overlying Pennsylvanian shale.

The present writer in his investigation of the El Dorado field[2] obtained evidence which is contrary to that described above, and hence his interpretation of the limestone portion of the Stapleton pay as of Mississippian age differs radically from that of Aurin, Clark, and Trager. Stated briefly, the evidence described in the report on the El Dorado field shows that in the Stapleton pay zone the limestone overlies the sandstone and that the deeper rocks continue to be sandy, which is exactly opposite to that described by Aurin, Clark, and Trager. Either the present writer or Aurin, Clark, and Trager have drawn conclusions from mistaken evidence.

In view of this contradiction of evidence presented in the two publications, the present writer wishes to bring attention to the information upon which his conclusions were based and to reiterate that this evidence indicates the Mississippian age of the limestone that forms the major part of the Stapleton pay zone.

In the El Dorado report the Stapleton pay is described as a zone of porous rock at the top of an eroded surface of pre-Pennsylvanian formations. In some wells the pay rock is entirely a cherty dolomitic limestone. In other wells the pay rock consists entirely of a quartzose sand. In still other wells a small amount of the limestone is first penetrated and the drill then passes into the sandstone. The definite statement is made on page 37 of the report, and this statement is still valid so far as the writer is aware, that in wells where both limestone and sandstone constitute the pay, the limestone overlies the sandstone.

Some of the evidence covering this point on which the present writer made his interpretaion is given in detail on pp. 33 and 34 of his report. Equally definite evidence was found in cuttings from three or four additional wells. The fact that this limestone is found to be thick in some places, thin at other places, and completely missing at still other places, indicated to the writer that the limestone was a remnant of an eroded formation left on the top of the El Dorado anticline after this fold had been subjected to erosion prior to Cherokee time. Its cherty nature and the correlation evidence given graphically on plate VI of the report, seemed to indicate, although it did not conclusively prove, its Boone age. This correlation evidence would need be more detailed to prove conclusively its Boone age, and even more detailed to disprove it

[1]Aurin, F. L., Clark, G. C., and Trager, A. E., Notes on the subsurface pre-Pennsylvania stratigraphy of the uorthern mid-continent oil fields: Am. Assoc. Petroleum Geologists Bulletin, vol. 5, No. 2, pp. 143-144, 1921.

[2]Fath, A. E., Geology of the ElDorado oil and gas field, Butler County, Kansas: State Geol. Survey of Kansas Bull. 7, 1921.

in favor of the more radical conclusion reached by Aurin, Clark, and Trager that the Boone is completely beveled and present only low down on the flanks of the El Dorado anticline. In view of the present difference of opinion, it is to be regretted that the details of their evidence covering this point were not published in order that its value could be appraised. An additional point that should be noted is that the limestone of the Stapleton pay is almost entirely cherty dolomitic limestone, whereas the Ordovician limestone with which Aurin, Clark, and Trager have correlated it is found in most places other than the El Dorado field as a siliceous limestone. Until contrary paleontologic evidence is obtained or until sufficiently detailed well log evidence is published to show that the Boone is completely beveled and present only low down on the El Dorado anticline, there is no reason for concluding that the limestone of the Stapleton pay is other than the Boone of Mississippian age.

The age of the underlying sand, which in places constitutes a part and in other places constitutes the whole of the Stapleton pay, was considered in the El Dorado report as of undetermined but pre-Boone age. This sand, on the basis of the evidence presented by Aurin, Clark, and Trager, could, tentatively, be considered the top part of the formatoin which they consider to be the Tyner of Ordovician age.

A. E. FATH

OIL WELL IN SCOTLAND

The D'Arcy well 12 miles southeast of Edinburgh, Scotland, came in May 8th flowing high grade oil from a sand 1,810 to 1,820 feet. The sand has not been drilled through. This is the last test made by S. Pearson & Son for the British Government. It is located near the crest of an anticline. The production is estimated as several hundred barrels but the hole was full of cavings and 6 inch liner was set a 1,765 feet in an 8 inch hole. Production comes from the Calciferous series. The oil is slightly lower gravity than that at Hardstoft, England, but contains more paraffin wax.

This well is 300 miles north of the Hardstoft well in Derbyshire which is still flowing about 3 barrels a day. Other tests have been abandoned: 7 in Derbyshire, 2 in Straffordshire and one at West Calder, 19 miles southwest of Edinburgh in the oil shale country. The West Calder well was not drilled deep enough to test the formations underlying the oil shales.

SIDNEY POWERS.

DISCUSSION

THE NECESSITY FOR ENGINEERING IN DEVELOPING OIL AND GAS PROPERTIES

Much has been said and written in the past ten years regarding the need of more scientific methods of drilling wells and the extraction of oil and gas. We have all recognized that the geologists or petroleum engineers are too far apart from the driller and the practical operator. Anyone familiar with the petroleum industry knows that it has suffered for lack of practical application of engineering principles and that there is much careless and inefficient development work being done, even at the present time. The fact is that we are making no particular progress in bringing our practical work up to a higher engineering level; we are comparatively at a standstill and will remain at a standstill until we are thoroughly awake to the situation.

We are accused by our British competitors of drilling our wells in a very slipshod manner; they tell us that we pass up many important oil and gas shows because of our present methods. Unfortunately, we are, generally speaking, guilty of this practice and we should all begin a campaign that will give better results.

The petroleum geologist has made rapid strides in the past ten years. Though handicapped by poor log records, obtained from the practical end, he has, nevertheless forged ahead and is today far in the lead of the driller. Had the latter kept abreast of the geologist, it is safe to say that the oil industry would be much farther along the road than it now is. Any geologist, at all familiar with log records will bear out the truth of this assertion.

How then can we improve the practical end of the industry and bring it up to where it belongs? We are, in the future going to do deep drilling in many parts of the United States and we may expect deep production. Is it not high time for us to consider more seriously the necessity for engineering in exploitation and production work?

Take the case of the mining engineer. He is a graduate of some mining college, who has a working knowledge of Geology, Mechanical Engineering, Electrical Engineering, Chemistry and Civil Engineering. The important thing is that he gets underground and learns from practical experience the work of timbering, mucking machine and hand drilling etc. In fact, he goes to school at the mine plant for several years after having been graduated and until he does know the practical end, he is not properly a mining engineer.

This is exactly the sort of man we need to go into our oil fields and who will stay there, on the derrick floor and on the property until he is fully capable of filling any job from "roughneck" to driller. This practical experience should not be less than three years but when this time is completed, we will hear from such men. They will apply their theoretical engineering knowledge to the job and the job will be the gainer.

We have too few of these men in the industry. How many engineers of your acquaintance can hold down a job as driller? The tendency of engineers and geologists has been and is, to dodge this sort of work and by the way, a good practical working knowledge of drilling wells and producing wells would not come amiss for the geologist, either. These remarks apply particularly to rotary drilling. Fortunately, standard drilling is better done but there is room for improvement in the latter, too.

In addition to the practically educated petroleum engineer, there should be a decided and united effort to reach the practical driller and to educate him as far as possible. The writer recognizes the fact only too well, that many managers who are in control of properties, are badly in need of an engineering education themselves. There is no excuse, for instance, for a driller to turn in a drilling report showing "rock" or "hard rock" or "soft streak" as we so frequently note. Neither is there any excuse for the manager to accept such a report. Both men should be made to realize the importance of accurate and complete records. The writer recalls that a certain big company operating in the Ranger, Texas field did not have the casing records or logs of a number of wells which were drilled. When these wells were gone into later, the clean out crews had not the faintest idea of the casing or depths of pay. Such carelessness of course is inexcusable but, unfortunately, it has been too often the case.

It is not here intended to call attention specifically to numbers of other details where improvement is vitally necessary but rather to point out a common sense way to educate the men who need it so badly.

In the first place, our young graduates should go right into the oil field and stay there until they actually know the drilling and producing end of the business. They are the managers of the future and we need many of them right now. We need engineers who have specialized in Electrical, Mechanical and Civil Engineering and who are willing to continue through to a thorough education in all phases of the business of producing oil. Their presence in the industry will mean much and we will suffer without their services.

As regards the present driller, many have not even an high school education, but at the same time there are many shrewd men in their ranks, who can be taught. For their benefit, a series of lectures could be undertaken at various centers and the companies employing them could well afford to pay their expenses while they are getting the benefits of the lectures. These would be given by men qualified by experience and knowledge to discuss fully the particular subjects allotted to them. The lectures could be given on Elementary Geology, Practical Drilling, under the heads of mud laden fluids, cementing, core barreling, testing formations, controlling oil or gas wells and collapsing pressures of casings, the proper care and use of machinery, proper firing of boilers and the efficient producing of oil. Such a series of lectures could be given

in three days and each lecturer would of course prepare charts, blue prints, etc., to illustrate fully every important point. The men could take notes which could be supplemented later by copies of the lecture and it would be the duty of the manager of the company to see that they either profited thereby or else were dropped from the pay rolls.

It is true that many drillers have no use for such information but there is no doubt but that, under proper conditions, they could be shown the necessity for a better understanding of the duties required of them. The only way to get accurate records is to educate the man who makes them. They should be either educated or eliminated from the industry as unsafe drillers.

BEN K. STROUD.

IS IT INJURIOUS TO CLOSE IN AN OIL WELL?[1]

Unqualified assertions that it is unsafe and unwise to shut in producing oil wells are frequently heard. Still more often the inference is made that such a procedure may be injurious, and that it is undesirable. The claim that if small wells are once abandoned they will not "come back" was advanced as one of the strongest arguments for a tariff on oil, during the period when Mid-Continent oil was selling for little more than half its present price. The oil-field strike in the fields of San Joaquin Valley, Calif., during September and October, 1921, provided an opportunity to observe how facts agree with theories. This strike resulted in the total cessation of operations for a month or more on a number of properties, and in partial paralysis of others. The effects of the shut-down in the various fields of the San Joaquin Valley are discussed by C. C. Thomas, E. Huguenin and R. M. Barnes in the chapter for February, 1922, of the Seventh Annual Report of the State Oil and Gas Supervisor of California.

The statistics and facts presented by the observers mentioned above leave no room to doubt that as a whole the shut-down was beneficial to the oil wells. A few wells that had been pumping a mixture of oil and water before they were closed in yielded nothing but water for a few days after they were reopened, but persistent pumping restored them to their original productivity. On the other hand, some wells that yielded nothing but water before thhey were shut in, and that were pumped merely to keep the general water level low, yielded some oil after they were reopened. Other wells that had yielded a mixture of oil and water before the shut-down yielded nothing but clean oil for a short time after pumping was resumed. However, the showings made by groups of wells were much more significant than those of individual wells. These wells showed a general increase both in total oil and total water produced per well, and also an increase in the percentage of oil to water.

[1]Published by permission of the Director, U. S. Geol. Survey.

On some leases there was a great increase in the yield of oil and a decrease in the yield of water.

In only one field was a decided decrease in oil output noted, and this was for only a portion of the field. In the area of high water production in the old Kern River field some difficulty was experienced in bringing the wells back to normal productivity. However, even in this area the period of subnormal output lasted only 20 to 30 days. Compensating it, the wells in the area of low water production in this field showed phenomenal gains in output, and two months after the wells had been reopened they were still yielding more than at the time they were shut down.

The conclusions regarding the Coalinga field voiced by R. M. Barnes seem to be applicable to all the fields affected by the strike. "From the data on hand it can be concluded that no material change in water conditions resulted to underground deposits . . . . because of the cessation of producing operations. . . . . The ultimate recoverable quantity of oil . . . . has not been decreased by the shutting in of wells, and production statistics indicate that the production, which was merely postponed during the period of the shut-down, will be recovered in many cases within a few months after resumption of pumping because of consistent above-normal production which many wells are showing."

K. C. Heald.

REVIEWS AND NEW PUBLICATIONS

OIL PROSPECTING IN MICHIGAN

In an article published in the Michigan Manufacturer and Financial Record of Apr. 22, 1922, Mr. R. A. Smith, State Geologist, presents a number of interesting facts relating to the search for oil in Michigan. Among other things he says:

"The bed rocks are covered nearly everywhere in the State by deposits of sand, gravel and clay, which make it difficult or impossible in most places to tell where the anticlines are in advance of drilling.

"There are anticlines at Port Huron, Saginaw and Seul Choix Point (Schoolcraft County). The first two yielded oil in small quantities, and with more complete exploration larger quantities of oil might be found. Anticline-like structures appear to be present at Allegan, near Niles; at Muskegon, and Manistee, on Little Traverse Bay; along Detroit, and in Monroe County. The oil found in the wells drilled near Deerfield appears to be on a pronounced anticline or a terrace-like fold, but its form, direction or size is as yet uncertain.

"Drilling operations are now going on in several places, and Michigan in the next few weeks or months may become a real producer of oil. In fact there is a well near Deerfield, in Monroe County, which is said to be yielding about four barrels of oil a day—very small, it is true, but the next well may be a much larger one. The oil formation is the same as in the famous Lima and Findlay oil fields of northwestern Ohio, hence there are good possibilities worthy of thorough testing, especially as a favorable "structure" for oil appears to be present.

"Another well near Mt. Clemens is down over 3,500 feet, but unfortunately it has a string of tools in the bottom of the hole. If these are gotten out it would probably take but a few days to reach the supposed oil sands. A third well, near Brown City, Lapeer County, is making rapid progress, and in a few weeks should be down to the oil formation. A fourth well is being drilled near Dey's Lake, Jackson County, to a depth of over 3,000 feet. It is already down more than 1,700 feet. Another well is soon to be started near Peck, Sanilac County, as soon as the weather permits.

"Another well is to be started on Paul Choix Point, about 15 miles east of Manistique. The different concerns are planning several tests in the vicinity of Manistee, where showings of oil were struck in several old wells drilled for salt. One of the wells spouted oil and water 150 feet in the air. All of these places have possibilities of oil.

"In 1914 oil was struck not only in several wells at Saginaw, but in no less than four sands. The quantity, however, was too small for profitable operations. The oil from one well was exceptionally high grade, equal in gravity to the average Pennsylvania crude. Likewise at Allengan oil was struck in several wells, but again in too small quantities. Two old salt wells at Muskegon have been seeping oil for years,

one of them nearly a barrel a week. The crude oil was used by a manufacturing concern for oiling its machinery. Several years ago oil was struck in small quantities in a number of wells in southwestern Michigan, but not in commercial amounts.

"With so many showings of oil it is reasonable to expect that somewhere in the State oil will be found in commercial quantities. Just where this will be no one can say in advance of the drill. Probably the unbroken chain of failures, however, is not wholly due to unfavorable geological conditions in the State as a whole, but in part to misguided, haphazard and crass-brained exploration. With more intelligent development it is very possible that the State would have been a producer of oil long ago."

A TREATISE ON PETROLEUM

Sir Boverton Redwood

The Fourth Edition of the above Treatise is published by J. B. Lippincott Company, at a cost of $39.00, postage extra (mailing weight 9 lbs.). The three volumes consist of 364, 375 and 612 pages, respectively, and are illustrated by maps of various portions of the world including a map of the United States in four sections—scale: 1—2,500,000. Owing to the death of Sir Boverton Redwood as the revised edition was going to press, the work has been edited by Sir F. W. Black. The section of twenty-four pages dealing with the United States, has been written by geologists of the U. S. Geological Survey with special attention from O. B. Hopkins. The first volume comprises an historical account of the petroleum industry, the distribution of petroleum, its physical and chemical purpose, and its origin. Volume 2, treats of the production and refining of petroleum, shale oil and allied industries and with the transport, storage and distribution of petroleum. Volume 3 describes the testing of petroleum and allied products, their uses, regulations regarding their testing, storage and transport and statistics of production. This is followed by a bibliography of 8,804 titles and an index of 35 pages. This monographic work is indispensible to any one interested in the occurrence and mining of petroleum outside of the United States and the bibliography is one of the most complete dealing with petroleum and its products.

S. Powers.

MUD LADEN FLUIDS AND TABLES ON SPECIFIC GRAVITIES AND COLLAPSING PRESSURES

Ben K. Stroud

Technical paper No. 1 of the Department of Conservation, State of Louisiana, discusses in 14 pages the use of mud laden fluid and the collapsing pressure of casing. The pamphlet may be obtained free in Shreveport, Louisiana.

PRELIMINARY REPORT ON PROPOSED PIPELINE FROM THE MONROE GAS FIELD TO NEW ORLEANS

BEN K. STROUD and F. T. PAYNE

The Department of Conservation, State of Louisiana, has issued a mimeograph pamphlet 8½x10½ in size, discussing a proposed pipeline and giving estimates of the available gas supply in each of the gas fields of Louisiana. The description of wells in these fields and the estimates of recoverable gas are of great value as a reference. The 38 pages of text are followed by charts and by a map of Louisiana, scale of 12 miles to the inch, showing the location of the gas fields. This publication may be obtained free at Shreveport, Louisiana.

Bell, P. L. Colombia. A commercial and industrial handbook. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 206, 1921. 423 pp. Contains chapter (pp. 120 137) on petroleum, giving location of regions in which oil is found, description of surface indications topography and geology of oil districts, an account of oil-land concessions and developments in the past, explanation of oil-land titles and legislation, and discussion of operating costs and labor conditions.

Bownocker, J. A. Rise and decline in production of petroleum in Ohio and Indiana. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 108-119; discussion, pp. 119-121.

Gamba, F. P. The petroleum resources of Colombia. Petroleum World (Los Angeles), vol. 7, Jan., 1922, p. 7. Gives map showing location of known coal and oil deposits in Colombia.

Glenn, L. C. Oil fields of Kentucky and Tennessee. Trans. Am. Inst. Min. and Met. Eng., vol. 5, 1921, pp. 123-133; discussion, pp. 133-139. Gives history of attempts to develop oil in Tennessee and brief discussion of possibilities in the State. History of developments in Kentucky oil fields and some technologic data on the wells, concluding with a discussion of future possibilities.

Grimes, O. J. Utah's oil fields. Railroad Red Book, vol. 39, Jan. 1922, pp. 251-253. General review of developments in the State.

Herold, S. C. Petroleum in the Argentine Republic. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 40-44; discussion, pp. 44-46. Gives locations of the five fields of Argentina, mode of occurrence in each field, and an account of development in the Comodoro Rivadavia field.

Hunter, C. M. Oil fields of Persia. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 8-15; discussion, pp. 15-16. Gives history, geology, technology, production statistics, and brief discussion of future possibilities.

Liegerot, L. E. Early history of the Mid-Continent petroleum fields. The Mid-Continent Year Book, (Mid-Continent Oil and Gas Association), 1921, pp. 13-15.

McBeth, R. S. Opening Spindletop with Lucas gusher; A lesson in perseverance. Nat. Petroleum News, vol. 13, Sept. 21, 1921, pp. 51-52. Gives history of the drilling of this famous well.

MacLeod, W. A. Economic mineral resources of northern Saskatchewan. Canadian Chem. and Met., vol. 6, Feb. 1922, pp. 35-37. Review of a recent survey disclosing the presence of carbonaceous sands, oil shale, and possible liquid petroleum and natural gas.

Macready, G. A. Petroleum industry of Trinidad. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 58-67; discussion, pp. 67-68. General review of the industry in Trinidad.

Mid-Continent Oil and Gas Association. The Mid-Continent Year Book 1921. Tulsa, Oklahoma, December, 1921. 192 pp. Historical and statistical data on the Mid-Continent field, and annual reports of the Mid-Continent Oil and Gas Association and the Osage Oil and Gas Lessees Association. Includes the following special articles: Use of Low-pressure gas burners in oil field boilers, by G. S. Brewer, M. P. Youker, and C. E. Beecher. The land leasing Act and its interpretation, by P. Q. Nyce. Federal Reserve Board gives oil industry recognition, by F. W. Bryant. Impressions of an independent operator, by J. D. Collett.

Petroleum World (London). Poland's oil deposits. Vol. 19, Feb. 1922, p. 82. Quotes Polish Economic Bulletin, giving extent of the Polish oil fields, names of oil zones, and possible future supply.

Redfield, A. H. European ichthyol industry during and after the war. Vol. 100, Aug. 8, 1921, Sec. 1, p. 25. Gives location of Austrian deposits of "ichthyol shales," brief history of their exploitation, and statistics of production of Austrian shale, crude and refined oils, 1909-1919. Gives also location of German and Swiss deposits of shale and brief account of their exploitation, and an analysis of Swiss shales; location of Italian deposits, account of their exploitation, and production figures for Italy, 1913-1919.

Schurz, W. L. Bolivia. A commercial and industrial handbook. Bureau of Foreign and Domestic Commerce, Special Agent Series, No. 208, 1921. 260 pp. Contains chapter (pp. 138-143) on petroleum, giving account of attempted developments, location of the oil fields, principal provisions of the Bolivian petroleum laws, statement of American, British and Chilean interests in the field, and discussion of transportation problems in various fields.

Smith, L. E. Three years likely to see Colombia factor in oil production. Nat. Petroleum News, vol. 13, Nov. 93, 1921, pp. 23-24,27-28. Describes conditions and discusses possibilities in Colombia.

Thompson, A. B. and Madgwick, T. G. Oil fields of Russia. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 17-37; discussion, pp. 37--39. Gives some of the history of petroleum exploitation in Russia, discusses the geology of the fields, describes drilling methods and gives yield per acre in Baku fields.

Varley, Thomas, Stevenson, C. C., and Reid, W. S. Utah's mineral wealth. Issued by the Commercial Club Chamber of Commerce, Salt Lake City, 1921. 32 pp. Includes brief statement on oil shale in Utah.

Varnum, Henry. Search for petroleum in Florida. Oil and Gas Jour., vol. 20, Oct. 14, 1921, p. 76. Gives an account of various tests in the State and describes surface conditions and discusses possibilities of finding oil in paying quantities.

Wolf, A. G. The White Point gas field. Eng. and Min. Jour., vol. 113, Jan. 28, 1922, pp. 174-175. General description of the field, with discussion of future possibilities of both oil and gas in this vicinity.

Albertson, M. Isostatic adustments on a minor scale, in their relation to oil domes. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 418-420. Suggests theory of origin of domal structures, particularly of certain domes observed in the Pennsylvanian area of Missouri.

Ashley, G. H. Deep-seated oil and gas horizons in the Appalachians. Nat. Petroleum News, vol. 13, Nov. 2, 1921, p. 60. Abstract of paper before the American Institute of Mining and Metallurgical Engineers.

Burnham, R. The oil shales of Colorado. Bulletin, Union Oil Company of California, January, 1922, pp. 7-10, 20. Characteristics and future possibilities of the oil shales of Parachute Creek, Garfield County, Colorado. Reprinted in California Oil World, vol. 14, Feb. 16, 1922, pp. 3, 6.

Cheney, C. A. Petroleum in Colbert Co., Alabama. Oil News, vol. 9, Oct. 5, 1921, pp. 36, 38, 40, 43 Discusses possibilities of northern Alabama, particularly Colbert County.

Clapp, F. G. Geology of Cement oil field. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 156-164. Reviews conditions, developments and possibilities in this field.

de Oliveira, E. P. Petroliferous rocks in Serra da Baliza. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 241-244. Describes oil indications in Brazil.

Deussen, Alexander. Salt domes of Texas and Louisiana. Oil Weekly, vol. 24, Jan. 21, 1922, pp. 11, 16, 18. Gives brief history of these domes, list of domes in Texas and Louisiana, data on discovery and production of domes of the Gulf Coast, description of structure and outward appearance of domes in general, and brief discussion of prospects of finding new ones.

Dill, R. G. Oil in southern Colorado indicates new field. Oil Trade Jour., vol. 12, Oct. 1921, p. 38. Tells of oil discovery in Montezuma County, Colorado, and discusses possibilities of the region.

Easton, H. D. Is Mississippi to be an oil state? Oil Weekly, vol. 23, Oct. 29, 1921, pp. 12, 26, 28. Discusses geology of the state, and possibility of finding oil.

Engineering and Mining Journal. Possible indications of oil in Mississippi. Vol. 113, Feb. 11, 1922, p. 254. Summary of observations made by the U. S. Geological Survey and the Mississippi State Geological Survey.

Grimes, O. J. Colorado oil cheers Utah. Petroleum Age, vol. 8, Oct. 1, 1921, pp. 31-33. Tells of a discovery well near the Colorado-Utah line in formations similar to those of the San Juan field, Utah.

Hackford, J. E. Nature of coal. Trans. Am. Inst. Min. and Met. Eng. vol. 65, 1921, pp. 217-222; discussion, pp. 223-228. Results of a study of petroleum and derived bitumens bearing on the fundamental nature and origin of coal and the relationship between coal and petroleum.

Hancock, E. T. The Lance Creek oil and gas field, Niobrara County, Wyoming. U. S. Geol. Survey Bull. 716, 1921, pp. 91-122. Published also as separate Bull. 716-E, 1920. Gives stratigraphy and struture of the field, describes the oil sands as shown by well records, makes suggestions for development, and gives analysis of the oil.

Hancock, E. T. The Mule Creek oil field, Wyoming. U. S. Geol. Survey Bull. 716, 1921, pp. 35-53. Published also as separate Bull. 716-C, 1920. Gives geology of the field, especially the structure, and a description of the porous beds that may yield oil.

Hancock, E. T. The Upton-Thornton oil field, Wyoming. U. S. Geol. Survey Bull. 716, 1921, pp. 17-34. Published also as separate Bull. 716-B, 1920. Gives stratigraphy and structure of the field and data on oil development.

Hume, W. F. The geology of the Egyptian oil field. Jour. Inst. Petroleum Technologists, vol. 7, Dec. 1921, pp. 394-411; discussion, pp. 412-417. Gives general history of the fields, account of search for petroleum in Egypt, and detailed geological description and discussion. See also Petroleum Times, vol. 6, Oct. 15, 1921, pp. 541-543.

Jillson, W. R. Oil shale of Kentucky. Oil News, vol. 10, Feb. 5, 1922, pp. 36-37. Paper before the American Association of Petroleum Geologists, 1921. Describes the Kentucky shale, gives oil yield, and discusses future prospects.

Johnson, R. H. Water displacement in oil and gas sands. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 498-599; discussion, pp. 501-504. Duscusses consequences of displacing water in oil and gas sands.

Johnson, R. H. and Huntley, Stirling. Resume of Pennsylvania-New York oil field. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 151-154; discussion, pp. 154-155. Gives geology, grade of oil produced, natural gas and natural-gas gasoline production figures for Pennsylvania in 1916 and 1917, costs of drilling, and brief discussion of future possibilities.

Kerr, W. F. Experts fixing location of bank. Oil and Gas Jour., vol. 20, Sept. 30, 1921, p. 73. Gives report of Dr. Isaiah Bowman on the Red River bank submitted to the United States Supreme Court.

Matteson, W. G. Secondary intrusive origin of Gulf coastal plain salt domes. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 295-322; discussion, pp. 322-334. Explains the secondary intrusive origin theory and compares it with the previous theory of intrusive origin.

Melcher, A. F. Determination of pore space of oil and gas sands. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 469-489; discussion, pp. 490-497. Reports on an investigation of the physical factors of oil and gas, and especially of their sands, such as pore space, size of pores or permeability, retentivity, viscosity of the oil, temperature, pressure, thickness and area of the pay sand, water relations and capillarity.

Mining Magazine. Oil in Kimberly district. Vol. 25, Dec., 1921, pp. 361-363. Statement of recent investigators on conditions and possibilities in this part of western Australia.

Moore, R. C. Petroleum Resources of Kansas. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 97-107. Gives brief history of development in Kansas, geology of the fields, etc.

National Petroleum News. Dry holes show how Utah formations run. Vol. 14, Feb. 8, 1922, pp. 67-68. Gives log and correlation of deep tests drilled in Utah by the Ohio Oil Co.

Oil News. Petroleum in Hayti. Vol. 10, Feb. 5, 1922, pp. 41-42. Summary of geological reconnaissance made by the U. S. Geological Survey. See also Oil Weekly, vol. 23, Nov. 19, 1921, pp. 48, 78-79.

Oil Weekly. Possibility of production from Trinity sand not unreasonable. Vol. 23, Oct. 29, 1921, p. 11. Gives opinion of Dr. J. A. Udden regarding possibilities of the Trinity sand at Mexia, Texas.

Petroleum Times. The search for oil in Scotland. Vol. 6, Sept. 17, 1921, p. 401. Resume of paper by H. M. Cadell on "Evidence from recent bores in the Carboniferous rocks of Scotland," before the British Association, and of the discussion following the paper.

Rae, C. C. A possible origin of oil. Mining and Metallurgy, Feb., 1922, pp. 64-65. Abstract of paper to be presented at the New York meet-

ing of the American Institute of Mining and Metallurgical Engineers, February, 1922.

Reger, D. B. Carbon ratios of coals in West Virginia oil fields. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 522-526; discussion, pp. 526-527. Discusses the value of carbon ratios in determining the boundaries of possible oil deposits, and gives isocaro map of West Virginia.

Rich, J. L. The stratigraphy of eastern New Mexico—a correction. Am. Jour. Sci., vol. 2, 5th series, Nov., 1921, pp. 295-298. Challenges certain statements and correlations in paper by C. L. Baker, "Contributions to the stratigraphy of eastern New Mexico," Am. Jour. Sci., vol. 49, 4th series, Feb., 1920, pp. 99-126.

Ropes, L. S. The distillation of oil shale. Eng. and Min. Jour., vol. 113, Jan. 28, 1922, pp. 155-156. On the possibilities of further study of the effect of gas upon the segregation of oil from oil sands, suggested by an article by G. A. Thiel, "Gas an important factor in oil accumulations," Eng. and Min. Jour., vol. 109, Apr. 10, 1920, pp. 888-889.

Schnabel, E. Die Gase der Methanreihe im Mahrisch-Slowakischen Tertiar. Petroleum Ztschr. Jahrg. 17, Dec. 10, 1921, pp. 1299-1302. Describes occurences of natural gases in various parts of Moravia.

Semmes, D. R. Oil possibilities in northern Alabama. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 140-149; discussion, p. 150. Gives stratigraphy and structure of this region, discusses the significance of carbon ratios of coals there, gives location of favorable areas, an account of past and present development, and brief suggestions for future prospecting.

Shaw, E. W. and Ports, P. L. Natural-gas resources available to Dallas and other cities of central north Texas. U. S. Geol. Survey, Bull. 716, 1921, pp. 55-89. Published also as separate Bull. 716-D, 1920. Results of an investigation made by the Survey at the request of the mayor of Dallas on account of the shortage of natural gas in Dallas and neighboring cities during the winter of 1919-1920. Describes the fields supplying north Texas and other fields from which gas might be obtained.

Smith, W. D. Petroleum in the Philippines. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 47-54; discussion, pp. 54-57. Gives locations of all known occurrences, a brief account of previous investigations, a provisional stratigraphic column of the Philippines, and a tentative correlation of the Far Eastern Tertiary stratigraphy, including that of the Philippines.

St. Clair, Stuart. Irvine oil district, Kentucky. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 165-175. Gives geology of the district, mode of occurrence of the oil, and description of the Big Sinking Pool, and discusses economic conditions.

Washburne, C. W. Chlorides in oil-field waters. Oil News, vol. 9, Sept. 20, 1921, pp. 53, 56, 58. Reprint of paper before the American Institute of Mining Engineers, February, 1914.

Washburne, C. W. Oil-field brines. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 269-281; discussion, pp. 281-294. A discussion of some of the conclusions reached by R. Van A. Mills and R. C. Wells in U. S. Geological Survey Bull. 693, 1919, "The evaporation and concentration of waters associated with petroleum and natural gas."

Wheeler, H. A. The new Wamac oil pool in Illinois. Eng. and Min. Jour., vol. 113, Feb. 4, 1922, pp. 213-214. Tells of recent development in

the Centralia district of Illinois and discusses prospects of production from the new "Petro" sand.

White, David. Genetic problems affecting search for new oil regions. Trans. Am. Inst. Min. and Met., vol. 65, 1921, pp. 176-195; discussion, pp. 195-198. Discusses the following factors affecting the occurrence of petroleum: (1) Sufficiency of carbonaceous detritus and residues in the oil-forming rocks; (2) stage of carbonization of the organic matter in oil-bearing formations; (3) folding of the strata; (4) thickness of sedimentary formations; (5) conditions of deposition.

Williams, H. E. Oil-shales and petroleum prospects in Brazil. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 69-76; discussion, pp. 76-77. On the petroleum and shale resources of Brazil. Reprinted in Oil News, vol. 9, Feb. 5, 1921, pp. 36, 38, 40.

Williams, H. E. Will Campos be another Tampico. Oil and Gas Jour., vol. 20, Oct. 21, 1921, pp. 78-79. A study of the possibilities of the Parahyba Embayment, which consists of the level plains centering around the city of Campos, Brazil.

Winchester, D. E. Geology of Alamosa Creek valley, Socorro County, New Mexico, with special reference to the occurrence of oil and gas. U. S. Geol. Survey Bull. 716, 1921, pp. 1-15. Published also as separate Bull. 716-A, 1920. Gives stratigraphy and structure of the region and discusses oil and gas possibilities.

Woodruff, E. G. Petroliferous provinces. Trans. Am. Inst. Min. and Met. Eng., vol 65, 1921, pp. 199-204; discussion, pp. 204-216. Analyzes from a regional standpoint, some of the factors that control the presence or absence of oil pools, discussing first the origin of petroleum as it occurs in definite regions, then the regional arrangement of reservoir strata, and, finally, the areal arrangement of structures. Gives map of North America showing petroliferous provinces.

Wray, D. A. Geology and mineral resources of the Serb-Croat-Slovene State. London, The Department of Overseas Trade, 1921 (?). 110 pp. Prepared for the British Economic Mission to Serbia by a member of the Geological Survey of Great Britain. Quoted in Petroleum Times, vol. 6, Sept. 10, 1921, p. 366; Nov. 5, pp. 649-651. Petroleum World (London), vol. 19, Feb., 1922, pp. 49-50, 52-53.

Alvey, G. H. and Foster, A. W. Barrel-day values. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 412-416; discussion pp. 416-417. On valuation methods.

Ambrose, A. W. Analysis of oil-field water problems. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 245-265; discussion, pp. 265-268. Study of the occurrence and sources of water in oil fields and of methods of preventing damage to wells.

Beal, C. H. Essential factors in valuation of oil properties. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 344-352. Discusses the following important factors: (1) amount of oil the property will produce; (2) amount of money this oil will bring (based on the future prices of oil). (3) development and production costs; (4) rate of interest on the investment; (5) the retirement or amortization of invested capital; and (6) the salvage or "scrap" value of equipment when the property is exhausted.

Beal, C. H. and Nolan, E. D. Application of the law of equal expectations to oil production in California. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 335-343. Explains the method used in

demonstrating the following laws: "If two wells under similar conditions produce equal amounts during any given year, the amounts they will produce thereafter, on the average, will be approximately equal, regardless of their relative ages;" and gives metheds by which curves constructed in accordance with this law can be used easily and accurately.

Bowie, C. P. Oil-camp sanitation. Bureau of Mines Tech. Paper 261, 1921. 32 pp. Describes various unsanitary conditions in oil camps and discusses their causes and remedies.

Case, J. B. Report on Huntington Beach oil field, Orange County, California, with special reference to lack of definite subsurface information after eighteen months of drilling activity. Summary of operations, California oil fields. Monthly chapter, Seventh Annual Report of the State Oil and Gas Supervisor, November, 1921, pp. 8-43. Deals with the various phases and peculiarities of development of this field, which led to its present condition, and shows some of the causes of lack of information on underground conditions. Data used are as of August 13, 1921.

Collom, R. E. The Huntington Beach oil field. Summary of operations, California oil fields. Monthly chapter, Seventh Annual Report of the State Oil and Gas Supervisor, November, 1921, pp. 5-7. General survey of conditions of development in this field.

Ellzey, B. V. Electric drilling effects tremendous saving. Oil Weekly, vol. 24, Jan. 21, 1922, pp. 34, 38, 40. Gives data on wells at Long Beach, California, and in Kansas, and description of electrical equipment generally used, with cost of installation and operation.

Ellzey, B. V. Why California deep wells are profitable. Oil Weekly, vol. 24, Jan. 21, 1922, pp. 62-63. Dicusses the following four major factors which combine to make California wells profitable: (1) Tenure of life of wells. (2) Availability of duplicate production from many sands in same wells. (3) Ideal operating methods. (4) Stable market schedules.

Estabrook, E. L. Production problems in the Grass Creek oil field. Mining and Metallurgy, Feb. 1922, pp. 65-66. Abstract of paper to be presented at the New York meeting of the American Institute of Mining and Metallurgical Engineers, February, 1922. Brief account of the geologic and production problems encountered in the Grass Creek oil field, methods used in their solution, and results obtained.

Hartnagel, C. A. New York State Geologist plans to aid producers in recovery of petroleum. Nat. Petroleum News, vol. 14, Feb. 1, 1922, pp. 53-54. Discusses some of the factors which enter into the application of artificial methods of increasing the recovery of oil.

Hill, H. H. Possibilities of chemical research in producing branch of oil industry. Oil Weekly, vol. 24, Jan. 21, 1922, pp. 15-16. Discusses the various problems in oil production which may be solved by chemical research, such as the study of oil-field waters, oil field emulsions, corrosion of pipe, and cementing materials.

Johnson, R. H. Variation in decline curves of various oil pools. Trans. Am. Inst. Min. and Met. Eng., vol 65, 1921, pp. 365 369; discussion pp. 370-373. Arranges data of decline curves of oil wells in the United States so that various pools can be compared and draws conclusions.

Kelly, R. W. Accident prevention in the Associated Oil Company. Min. and Oil. Bull. vol. 7, Oct. 1921, pp. 657-660, 668. Tells of organized safety work of this company and its results.

Knapp, Arthur. Drilling and production technique in the Baku oil fields. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 459-466; discussion, pp. 466-468. Describes method of controlling gushers in these fields and calls attention to other interesting practices.

Knapp, Arthur. Modified oil-well depletion curves. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 405-410; discussion, p. 411. Discusses methods of plotting and using such curves.

Knapp, Arthur. Rock classification from the oil-driller's standpoint. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 424-429. Defines terms used by drillers and gives a tabulated summary of rock classification, showing general classes, rotary drillers' terms, cable drillers' terms, use in rotary and cable-tool drilling systems, and technical equivalents.

Matier, H. A. The Alexander "gasser." Bulletin Union Oil Company of California, vol. 1, Feb. 1922, pp. 3-6. Account of a gas blow-out near Santa Fe Springs, Calif. including discussion of the origin of natural gas and petroleum and the cause of such outbursts.

Mitchell, J. S. Prospecting for oil with the diamond drill. Eng. and Min. Jour., vol. 113, Jan. 7, 1922, pp. 18-19. Outlines advantages of the diamond drill as compared with other methods. See also Oil Weekly, vol. 24, Jan. 21, 1922, pp. 50, 52.

Munger, E. J. New boon to rotary found. Petroleum Age, vol. 8, Nov. 15, 1921, pp. 19-20. Tells of the use in California fields of precipitated calcium carbonate from sugar factories for mixing with rotary mud.

National Petroleum News. How one of the fiercest fires in history of Mexico was extinguished. Vol. 14, Jan. 18, 1922, pp. 65-66, 69. Account of the extinguishing of the No. 4 Toteco well of the Mexican Gulf Oil Company, in the southern district of Mexico.

National Petroleum News. New type segmental insulation proves successful in practice. Vol. 13, Nov. 9, 1921, pp. 29-30. Describes an entirely new type of segmental still and oil-field boiler insulation with the added advantage of not absorbing water, oil, or ,vapors, developed in Houston, Texas.

Oil Weekly. Drilling costs in various fields. Vol. 24, Jan. 21, 1922, pp. 54, 56, 60. Gives average costs as of December 15, 1921, for wells in California, Mexico, Oklahoma, Kansas, Texas and Arkansas.

Oil Weekly. New device for flowing wells being used in California. Vol. 24, Jan. 21, 1922, p. 66. Describes the Putman pneumatic lift.

Oil Weekly. Trinidad wells to have longer life. Vol. 24, Jan. 21, 1922, pp. 28, 32. Tells of the succesful use of screen and the handling of tools under heavy pressure through an arrangement of stuffing boxes in a Trinidad well.

Oliver, Earl. Appraisal of oil properties. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 353-360; discussion, pp. 361-364.

Pepperberg, L. J. Leaks in the oil fields. Oil Weekly, vol. 24, Jan. 21, 1922, pp. 21-22, 24, 34. On the importance of using economical and efficient methods in oil fields.

Rice, R. H. Estimating natural gas reserves. Oil and gas Jour., vol. 20, Sept. 30, 1921, pp. 80, 93-94; Oct. 7, pp 90-91. Discusses the subject under the following heads: Importance of knowing the quantity of reserve gas. The available data. The use of the data. Apparent variations from Boyle's law in the history of natural gas pools.

Ruedemann, Paul. Comparative barrel-day values. Oil and Gas Jour.

vol. 20, Oct. 28, 1921, p. 81. Explains method used in placing valuations on properties for taxation purposes.

Suman, J. R. Reverse return system of rotary drilling. Oil Weekly, vol. 24, Jan. 21, 1922, pp. 42, 44, 46. Explains principles of a new system of rotary drilling recently developed in the Gulf Coast region in the work of exploration for sulphur, pointing out its adaptability in certain phases of petroleum exploration.

Veatch, A. C. Petroleum resources of Great Britain. Trans. Am. Inst. Min. and Met. Eng., vol. 65, 1921, pp. 3-6; discussion, pp. 6-7 Gives status of oil development in England to date, future commercial prospects, and characteristics of the oil from the Hardstoft well.

Whitney, R. H. Old wells of Oklahoma and Kansas. Oil and Gas Jour., vol. 20, Oct. 7, 1921, pp. 82-85. Reviews records of many of the old wells of these States which indicate the lasting qualities of certain sands.

THE ASSOCIATION ROUND TABLE

PROFESSIONAL ETHICS

The subject of professional ethics or morals assumes that there are, or ought to be, standards of conduct. But obviously there can be no authority in such a matter except that which the profession sets up for itself as a result of consensus of opinion of men of judgment and of experience. There are analogies from the professions of medicine and law, and there are such standards as the U. S. Geological Survey and some State Surveys try to maintain regarding the private use or non-use of information gained at public expense. But, broadly speaking, the problems are peculiar to the profession and hence analogies do not cover them; and furthermore, some of the problems do not arise at all in the public services, but are met only in private practice or employment. The young man in the profession may have had no advice and little experience to guide him away from bad practices. A few older men may feel that sentiment is too ill-defined to bring serious embarrassment as a result of any conduct, or that no professional obligation ought to count against temporary self-interest. Apparently evils have crept in and assumed such proportions that this association is seriously trying to see whether professional ethics can be crystallized into a code of conduct.

Any discussion of this problem will bring out differences of opinion as to where the emphasis should be placed, and indeed as to whether specific practices merit disapproval, but perhaps there will be sufficient agreement for the statement or the adoption of certain principles, at least, if nothing further is accomplished. The discussion should be founded on a charitable consideration for the opinions and the acts of others in the profession. Many a man has made initial mistakes unintentionally, and under force of circumstances which he thought excused him, and we particularly need his experience and his later judgment as to the results to the profession in case such practices were adopted generally. If the slate is wiped clean, can we not best formulate a code for the future?

It is particularly the conduct of the petroleum geologist that is before us, and it needs attention because so many have entered the profession in recent years, and because it offers so many tempetatoins to get rich quick, or to build up a lucrative practice. Probably we should view the whole field of those engaged in the work: the college proefssor, the geologist in government employ, in state employ, the consulting geologist, the geologist in company employ, the man investigating or operating for himself. It would seem entirely proper for this Association with its membership drawn from all of these sources, to adopt principles of general character and also those thought to apply to each of these kinds of employment in petroleum geology.

When the study gets down to kinds of work, it is evident that certain

problems are common to all, while others are limited to a particular kind. Some are simply matters of plain, common honesty, almost beyond dispute, while others involve matters about which opinions may conscientiously differ.

Among the common problems, even though elementary, it would seem to the writer desirable to discuss and adopt conclusions regarding the following:

1. Safeguarding confidential or private information, but making available to others *all* possible, *when* possible.

2. Taking personal advantages, directly or indirectly, of information acquired for another without his consent.

3. Receiving fees or commissions from both parties to a transaction, except with their knowledge.

4. Commending or condemning another geologist except on personal acquaintance with his work.

The other problems, which are more likely to develop differences of opinion, are numerous. Only a few will be mentioned.

1. Splitting fees or commissions for geological reports.

2. Should not one protect himself and profession by requiring that a report may only be publishd, or submitted for valuation purposes, with his knowledge and consent as to its completeness regarding essential facts?

3. Should one use different valuations on a property when appraising for taxation, sale, purchase, or as a basis of stock sales?

4. May one take personal advantage of information gained while in the full-time employ of another, even when gained incidentally?

5. Should one ever charge a high consulting fee for work of an elementary or subordinate character, or in an area with which one is not already intimately acquainted?

6. Should a State employee do any private oil work in his state?

These questions have been brought to mind by certain actual occurrences which have seemed to me to be harmful if generally indulged in, but regarding which it may be difficult and perhaps undesirable to formulate rules of conduct. They and others like them might well be referred to a committee on ethics and then reported for a sealed letter ballot by the Association.

F. W. DeWolf.

AT HOME AND ABROAD

A. H. NOBLE, Chief Geologist of the Corona, is in charge of the Mexican and Mesopotamian geological work for the Dutch Shell.

R. A. CONKLING has been on a pleasure trip in California.

GEORGE MORGAN, of the Empire Gas & Fuel Company, is in Mexico.

J. B. BURNETT, of the Aguila, is in the United States on a vacation.

A. M. MACKENZIE is with the Mammoth Oil Company, mapping Teapot Dome, Wyoming.

WILLIS STORM, of the Sun Company, is in Southern Texas.

P. L. APPLIN, of the Rio Bravo Oil Company is at Laredo, Texas.

W. E. HUBBARD, of Ardmore, expects to move to California in the fall.

W. E. WRATHER will spend the summer in Chicago.

F. B. PLUMMER has resigned from the Dutch Shell interests and is associated with independent operators at Houston, Texas..

THE OKMULGEE Geological Society elected new officers the first Friday in April, for 1922-3; President, Louis Roark; Vice President, Charles A. Warner; Secretary and Treasurer, H. S. Clark.

LEON F. RUSS, 25 Broadway, representing Frankel Brothers, of New York City, was in Shreveport in June, making a study of some of Louisiana's potential oil fields.

GEORGE A. ELLEDGE of Tampico, made a brief trip to Southwest Texas during June.

FERDINAND MORRIS is now in charge of the subsurface work for the Oklahoma Producing & Refining Corporation.

E. H. SELLARDS has prepared a subsurface structure contour map of Bexar County, Texas.

W. T. LEE is studying oil sands in Wyoming.

H. A. LEY is Chief Geologist for the Southwestern Gas Company of Independence, Kansas.

W. W. RUBEY, of the U. S. Geological Survey, is working in Wyoming.

A. C. VEATCH is mapping Teapot Dome, Wyoming, with the assistance of Stanley C. Herold and E. Eggleston Smith.

F. B. TOUGH, of the U. S. Bureau of Mines, has written a brief ex-

planation of the nature of the contract between the Mammoth Oil & Gas Company and the Secretary of the Interior.

The firm of BATES & LASKY has been dissolved. Mowry Bates is living at Lindsay, California. B. H. Lasky will continue the work of the partnership, in the Atco Building, at Tulsa, Oklahoma.

J. WHITNEY LEWIS, formerly of the firm of Hager, Bates & Lewis, is now General Manager of the New England Corporation, Ltd., at Maracaibo, Venezuela.

L. G. WELSH, formerly with the Transcontinental Oil Company, has opened an office as Consulting Geologist, in the Atco Building, Tulsa, Oklahoma.

RAYMOND C. MOORE is spending the summer in Utah, for the U. S. Geological Survey.

E. DEGOLYER has been in Europe on a short trip.

A. F. DIXON has been in San Domingo recently.

E. B. STILES on December first accepted a position with the Humphreys Mexia Company, with offices at 1320 Grand Southern Life Building, Dallas, Texas, to organize a sub-surface department similar to that in the Bureau of Economic Geology, at Austin, Texas.

WALTER J. ALLEN is geologist for the Shaffer Oil & Refining Company, at Tulsa, Oklahoma.

LUTHER WHITE has resigned from the Oklahoma Central Oil Company.

FRANK GREEN is now located at 605 Exchange National Bank Building, Tulsa, Oklahoma.

R. D. REED is with the R. B. Whitesides Company, Muskogee, Oklahoma.

KIRK & HOOVER have removed their offices to 432 Mayo Building, Tulsa, Oklahoma.

DAVE M. LOGAN has completed a Dutcher sand discovery well in section 26, T. 13N., R. 13E., near Okmulgee, Oklahoma.

CHESTER NARAMORE recently returned from China.

A. F. MELCHER, of the U. S. Geological Survey, has been studying sand conditions in the Burbank field.

W. P. HAYNES will attend the International Geological Congress Meeting in Belgium this summer.

J. ELMER THOMAS is spending the summer in Tulsa at the office of the Shaffer Oil & Refining Company.

STUART ST. CLAIR has been in China.

R. A. BIRK, of the Amerada Petroleum Corporation, has moved from Duncan to 411 Simpson Bldg., Ardmore, Oklahoma.

W. D. MILLER is geologist for the Planet Oil Company in Texas.

J. P. BOWEN is with the Simms Oil Company in Tulsa.

THE OKMULGEE GEOLOGICAL SOCIETY enjoyed a picnic at Tahlequah, July 1st.

G. E. EBMEYER, formerly with the Mexican Eagle Oil Company, has returned to the United States.

FRANK CARNEY, of the National Refining Company, is located in the Magnolia Building, Dallas, Texas.

PAUL WEAVER, of Tampico, has been in New York City on business.

DAVID DEAN discovered the Gray Bros. structure near Marlin, Texas.

IRVING PERRINE is spending the summer at Ithaca, N. Y.

E. H. BAUMAN is consulting geologist for the Oklahoma Petroleum & Gasoline Company and is living at Graham, Texas.

THE new Breckenridge lime well of the Humble Oil & Refining Co., 15 miles southeast of Albany, in Shackelford County, Texas, was drilled on subsurface structure. The Ibex Oil Company drilled the original well in this area on a small surface structure mapped by Hjalmar Abrahamson.

JOHN SUMAN has spent the month of July in California.

L. P. GARRETT spent part of the summer in the Yellowstone National Park.

ALEXANDER DEUSSEN has been in New York on a business trip.

E. T. DUMBLE has been in California.

R. T. HILL is spending the summer in California.

J. C. ROSS is making a barometric survey of the Okemah District, Oklahoma.

W. A. I. M. VAN DER GRACHT, who has recently been making his headquarters in New York City, is attending the International Geological Congress in Brussels.

W. C. SPOONER has been on a trip to Montana and Wyoming.

W. E. HOPPER has been in Wyoming and Montana.

F. J. MILLER is Division Geologist for The Texas Co. at Shreveport, La.

R. B. KELLEY, of the Bureau of Mines, has been transferred from Bartlesville, to Dallas.

W. R. MCLAUGHLIN is in Shreveport.

F. H. BOSTICK is doing subsurface work for the Standard Oil Co. of Louisiana.

H. G. SCHNEIDER, of the Amerada Petroleum Corporation, is working at Shreveport, La.

C. C. CLARKE is representing the Roxana Petroleum Corporation in Mississippi.

L. E. WELLS is with the Arkansas Natural Gas Co. in South Louisiana.

H. D. EASTON, of Shreveport, is working in Mississippi.

RICHARD JONES, of the Humble Oil & Refining Company is in Laredo, Texas.

H. N. SPOFFARD, of the Gladys Belle Oil Co., has returned from El Dorado, Arkansas, to Tulsa.

J. O. NELSON has returned to Shreveport from a business trip to Pittsburgh, Pa.

A. P. WRIGHT, of Tulsa, has been in New York City on business.

K. C. HEALD represented the U. S. Geological Survey at the Osage Sale, June 28th.

WILLIAM D. GRAY has resigned from the Riverland Co. to be an independent oil producer.

A. O. HAYES, formerly of the Geological Survey of Canada and later of the Whitehall Petroleum Corporation, is spending the summer at Coronado, California.

DAVID WHITE has been in Kentucky.

M. Y. WILLIAMS, of the Geological Survey of Canada, is engaged in petroleum work in the Canadian Northwest.

A. RODGER DENISON is office geologist with the Amerada Petroleum Corporation in Tulsa.

J. M. HAROLD is Chief Geologist of the Comar Oil Co.

EDWIN KIRK, of the U. S. National Museum, has recently returned from the Argentine Republic.

R. A. CONKLING is spending his prescribed six months away from the Mid-Continent field.

THE BARTLESVILLE Office of the U. S. Bureau of Mines has prepared a peg model of the Slick oil field, Oklahoma.

O. M. EDWARDS, of the Sun Co., has left Tulsa temporarily.

MARVIN LEE, of Wichita, Kansas, spent part of the summer near Laredo, Texas.

C.W. CLARKE, and DAVE LOGAN have formed a partnership for consulting work at Okmulgee, Okla.

ARTHUR BURRESS is working at Ardmore.

A. C. TROWBRIDGE is examining the delta of the Mississippi River for the U. S. Geological Survey in co-operation with the War Department.

C. E. DECKER has been conducting a field party in the Arbuckle Mountains.

RICHARD HUGHES spent his vacation in Colorado.

THE DIXIE Oil & Gas Co. will drill on the Scotland Seep structure in Telfair County, Georgia, 100 miles southeast of Macon. There is an excellent seepage of both oil and gas from the Alum Bluff formation, of the Oligocene, which is described by J. P. D. Hull and L. P. Teas in a special report of the Geological Survey of Georgia, published in 1919, entitled: "A preliminary report on the oil prospect near Scotland, Telfair County, Georgia."

R. C. SCHROYER, of the Roxana Petroleum Corp., will work in Louisiana.

C. O. DOUB is associated with Foster, Reiter & Sneed at 707 First Nat'l. Bank Bldg., Tulsa, Okla.

H. B. FUQUA is with the Gulf Production Co. at Wichita Falls, Texas.

R. M. BUTTERS is in Laredo, Texas.

M. R. GOLDMAN is working with Frank Reeves at Big Sandy, Mont.

C. R. LONGWELL and W. W. RUBEY are studying the structure of a portion of Wyoming adjacent to the Black Hills.

RUSSELL S. KNAPPEN is mapping structure in the Big Horn basin, Wyoming, for the U. S. Geological Survey.

DAVID WHITE has been designated by the Secretary of State as delegate to represent the Government at the International Geological Congress to be held in Brussels, August 10-19. Mr. and Mrs. White sailed July 29.

A. E. FATH is working for the Standard Oil Company in Poland. He sailed early in June.

M. M. ORR is on a brief trip to Oklahoma and will return to Panama for the Standard Oil Company.

BURTON HARTLEY, of Tulsa, has been in Kentucky on professional work.

W. B. WILSON, of the Gypsy Oil Co., is working in Montana.

JAMES L. TATUM, formerly with the Mexican Eagle Oil Co., is now with the McMan Oil Co., of Tulsa.

Dingwell Petroleum Producing Corp. will make a test with a diamond drill in the northwest corner of section 25, T. 6 S., R. 6 W., Jefferson Co., Okla.

WM L. CLARK of the Phillips Petroleum Co., is working at Bristow, Okla.

R. H. WOOD has been in Washington.

E. G. WOODRUFF, of the Producers & Refiners Corp., has been in Mississippi.

FRANK C. WIEST is with the Freeborn Engineering Co.

DONALD F. MACDONALD has been seriously ill in Rome, Italy.

S. W. WILLISTON, JR., is working in Texas.

D. D. CONDIT, of the Whitehall Petroleum Corp., is in California on a business trip.

J. E. BRANTLEY has returned from Mexico and is consulting geologist for the Atlantic Refining Co., with headquarters in Philadelphia.

MARVIN WELLER has returned from the Punjab, India.

J. O. LEWIS delivered a series of lectures on petroleum at the Massachusetts Institute of Technology.

E. A. TRAGER has been in Tulsa on a vacation.

ELIOT BLACKWELDER is in Ottawa, Kansas, where he is interested in some shallow field properties.

ROBERT E. GARRETT, 905 Petroleum Bldg., Tulsa, is engaged in consulting work.

WM. J. MILLARD of Tulsa, is doing consulting work.

K. P. HANSEN, geologist with the Mexican Eagle Oil Co., at Tampico, Mexico, since March 1920, died of typhoid fever June 26th, in Mexico.

Mr. Hansen was employed by the Minas Dolores, Matehuala, San Luis Potosi, Mexico, before joining El Aguila.

S. J. CAUDILL is spending the summer in the East.

K. D. WHITE is in the Argentine with the Standard Oil Co. of New Jersey.

GEO. E. BURTON and D. K. GREGER, of the Roxana Petroleum Corp., have been examining the Glenn formation, near Ardmore. Mr. Greger and Dr. Erni expect to publish a paper on the Glenn.

L. H. WHITE is spending the summer in Colorado.

J. M. HEROLD was appointed Head Geologist of the Roxana Petroleum Corporation, on July 15th.

PROF. R. D. SALISBURY, who for some weeks seemed to be slowly recovering from a severe heart attack, suffered a relapse about July 10th and since that time he has been very gravely ill.

EUGENE LILLY has returned to his home in St. Paul, Minnesota, after a year and a half in Palestine and Egypt.

W. H. EMMONS is spending the summer in Europe.

WOOD STANLEY is in charge of the geological work in Southwest Texas for the Gulf Production Company.

C. T. LUPTON has returned to Denver, Colorado, after a trip to Northern Mexico and the Laredo district of Texas.

M. L. FULLER has been traveling in England and on the Continent since last March. He recently returned to London from points in Spain and on the Bay of Biscay and does not expect to return to Brockton, Mass., until late in the fall.

HENRY HINDS is in Venezuela.

CARL W. CLARK has his office in the National Supply Building at Okmulgee, Oklahoma.

HENRY CONKLING is with the Roxana Petroleum Corporation at Okmulgee, Oklahoma.

J. F. ROBERTS, 205 S. Cheyenne St., Tulsa, Okla., mounts an up-to-date production map of Ts. 8-16 N., Rs. 8-14 E., inclusive (63 townships) in a book 7½x4¼x1¼ inches in size for $35.00. The scale of the maps is 1⅛ inches to the mile.

E. W. SHAW has been in Tulsa.

WM. D. GRAY mapped the structure in sec. 34, T. 23N., R. 8W., Osage County, Okla., where a new Wilcox sand well has been completed.

CHESTER W. WASHBURNE

GEOLOGIST

2 RECTOR ST. NEW YORK

C. MAX BAUER

GEOLOGIST

MID-NORTHERN OIL CO.

BILLINGS, MONTANA

FRANK W. DEWOLF

STATE GEOLOGIST OF ILLINOIS

LIMITED CONSULTING WORK ON PETROLEUM AND MINING GEOLOGY AND APPRAISALS IN STATES OTHER THAN ILLINOIS.

708 S. BUSEY AVE. URBANA, ILLINOIS

JOSEPH A. TAFF

CHIEF GEOLOGIST
PACIFIC OIL, ASSOCIATED OIL, AND AMALGAMATED OIL COMPANIES
GEOLOGIST
SOUTHERN PACIFIC COMPANY

NO ADDITIONAL WORK ENTERTAINED EXCEPT CONSULTATION.

79 NEW MONTGOMERY ST. SAN FRANCISCO

CARL B. ANDERSON

GEOLOGIST AND

PETROLEUM ENGINEER

42 BROADWAY NEW YORK

JAMES L. DARNELL
ARTHUR EATON

ENGINEERS

170 BROADWAY NEW YORK CITY

W. E. WRATHER

PETROLEUM GEOLOGIST

6044 BRYAN PARKWAY

DALLAS, TEXAS

IRVINE E. STEWART

GEOLOGIST

BILLINGS, MONTANA

TECHNICAL SERVICE

COAL, GAS, PETROLEUM
SURVEYS, ENGINEERING, CONSTRUCTION, ANALYSES, APPRAISALS
W. ELMER EKBLAW, GEOLOGIST
CHARLES H. KNOWLES, ENGINEER
JUSTA M. LINDGREN, CHEMIST
HOME OFFICE: 210 GAZETTE BUILDING, CHAMPAIGN, ILLINOIS
FIELD OFFICES:
ROSS-GREEN BLDG., MEXIA, TEXAS
STATE'S HOTEL, EL DORADO, ARKANSAS

EUGENE WESLEY SHAW

GEOLOGIST

170 BROADWAY NEW YORK — 302 COSDEN BLDG. TULSA

FREDERICK G. CLAPP

30 CHURCH STREET

NEW YORK CITY

EDWIN B. HOPKINS

CONSULTING GEOLOGIST

25 BROADWAY NEW YORK CITY

JOURNALISM PRESS
UNIVERSITY OF KANSAS
LAWRENCE · KANSAS